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BENJAMIN FRANKLIN: THE PRINTER AT WORK.*

BY

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All of us who have given thought to Benjamin Franklin the printer, who have visualized him at case and press in Boston, Philadelphia, London, and Paris, have pondered that passage in the Autobiography in which he tells that in his boyhood his father so directed their walks together that in the course of them they might watch craftsmen of many sorts at their work. One may think with pleasure of that picture of father and son observing in the varied life of their town "the different ways that different things are done," the father improving the shining hour with observation and precept, the son—a happy and unusual circumstance—eager to know the why and wherefore of preliminary operations, the names of tools, the ends of curious processes, the validity of short cuts, and the convenience of rules of thumb. What an education that proved to be! "It has ever since been a pleasure to me," wrote the son long afterwards, "to see good workmen handle their tools." A few lines below in his great and simple record of success occur the words: "From a child I was fond of reading." These two interests are the key to the life of Franklin the printer. Interest in the trades and handicrafts alone might have kept him in his father's soap-boiling establishment or sent him to Newport to join his brother John in

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candlemaking; love of reading, untempered by his interest in practical mechanics, might have sent him into a learned profession or taken the edge off his zeal in the routine of a handicraft or in trade. But neither of these destinies was to be his. The return of Brother James from London with a printing-house, just at the right time, made it possible for Benjamin to engage in the practice of a craft in which his particular combination of interests might have its exercise. He was articled to James in his twelfth year, and soon had become a useful hand to his brother in all the varied employment of an eighteenth-century printing shop. With that discovery of aptitude a new life was foreshadowed for him and for the printing trade in America.

Though he had been trained to his craft, it is believed, in a London establishment, James Franklin's printing was never anything more than adequate, and frequently it was less. James was a journalist and a politician, without interest in the craft of printing beyond its utilitarian employment. Lacking any notable degree of taste, lacking curiosity, he was representative of the majority of contemporary printers in that he used his tools without distinction. Nevertheless, having learned their employment in England, he was able to pass on to his apprentice a thorough knowledge of the mechanics of printing. When Benjamin ran away after concluding that he had endured about as much as he could stand of brotherly correction, it is probable that he had assimilated all the typographical knowledge James had to give. He had learned not only how to print a newspaper, but how to edit and manage one. He had learned, moreover, the full round of his craft. When he went to work for Keimer in Philadelphia he was able to put in working order an old, shattered press, and go at once about the task of composition and the printing of the forms. The sense of superiority that comes from a comprehensive training appears in those words in which, after telling of his services to Keimer, he declares that his new employer was "a mere compositor, knowing nothing of presswork."

But if Benjamin had continued without interruption in his Philadelphia employment, there is no reason to believe that his workmanship would ever have advanced greatly

beyond the normal degree of skill which had prevailed in his time in Boston, where, in the hands of Samuel Kneeland, Bartholomew Green, Thomas Fleet, and Brother James, the craft was still at the ebb at which it had stood esthetically for the eighty years of its existence in British America. Throughout that period in England, new type had been expensive and, even for the well-to-do printer, hard to procure in quantity and variety. Not too good to begin with, the common English press was used, and abused, by most printers until it became a ramshackle instrument, leaking force at every joint, and incapable of rendering accurate results. English ink, too, was carelessly made, and paper was an article of import and correspondingly dear. Because of their distance from European centers all these deterrents to good performance were intensified in the American colonies. There, especially, paper economy demanded pages of the lesser formats, close set in letters of the smaller sizes. All too frequently, these were printed with muddy ink in a fashion that betrayed evidence of deterioration of the presses and of thoughtlessness in their operation.

The printers of Philadelphia were even less to be admired as technicians than those of Boston. Samuel Keimer, with whom Franklin first had employment, owned little skill in printing. The work of Keimer's rival, Andrew Bradford, was poor by any standards of the time. It may be that, sooner or later, Franklin's natural sense of decency and order, his intellectual clarity, his feeling for balanced form would have lifted him out of the class of these teachers and associates of Boston and Philadelphia. None the less, those of us who are interested in the progress of the craft of printing in America are grateful to the chance which in 1724 took this young journeyman to England and set him down, a serious and apt student of his craft, in the busy London printing establishment of Samuel Palmer.

There was a new spirit showing in the printing houses of England in those early years of the century. There as everywhere appreciation of good workmanship and the ability to produce it upon occasion had never completely died out. But the successive Press Restriction Acts of the seventeenth century had kept the craft at a standstill for generations.

Improvement in type design had been rendered unlikely by regulations which removed the spirit of competition from the industry of letter-founding. These acts had also confined the business of printing virtually to the city of London, and had allowed the Stationers' Company to encourage monopoly among its members in certain fields of publication. All forces combined to make the English printing trade non-competitive and, in consequence, indifferent to improvement in materials and processes. It is true that in 1683 Joseph Moxon, printer and typefounder, had created in his "Mechanick Exercises" a manual of printing and type making in which he urged his contemporaries to take thought of what they were doing so as to do it better. He had shown them how they might improve their presses, their type, and their ink, and how they might more effectively execute their composition and press-work, but because he himself knew little of the esthetics of printing, he had said little in his treatise about the designing of books and the niceties of the arrangement of type. He improved the technique and tools of type casting in his foundry but the design of his own letter was hardly better than that of his contemporaries and rivals. It seems certain that his splendid book, the pioneer of printing manuals, had little influence upon his immediate contemporaries. But other forces besides Moxon's pleas and prescriptions were at work. The last of the Press Restriction Acts expired in 1695, and the control of the publishing trade by the Stationers' Company began at about the same time to decline in its rigor. With the limitations of locality removed, presses were set up throughout the English counties in the first quarter of the eighteenth century and competition arose between London and the provinces. Furthermore, intelligent printers had taken up the study of the mechanics of their craft. In his "History of the Art of Printing," published in Edinburgh in 1713, James Watson showed that he was thoroughly familiar with Moxon's book of thirty years before, and did his master honor by reaffirming his recommendations in the matter of presses, type, and ink. In 1723 appeared at Saint-Omer, across the Channel, Dominique Fertel's "Science de l'Imprimerie," in which, among other original and valuable features, the details of type arrangement were discussed on

the basis of a tradition that had suffered less degradation in France than in any other country of Europe. About 1729, Samuel Palmer of London announced the publication of a history of printing of which the second part (never published) was to be, if I have read the prospectus correctly, a revision and modernization of Moxon, enriched by elements drawn from the book of Fertel.[1] But these literary events were not so important in the history of English typography as the fact that in 1720 John Watts, William Bowyer, and James Bettenham, three London printers, had lent £500 to William Caslon, a young engraver upon metals, for the purpose of establishing a type foundry. Five or six years later began to appear, in works printed by Bowyer, the clean, well-modelled, uniformly cast roman letter of William Caslon. That letter is not nearly so beautiful nor so imaginative in design as certain others of earlier and later date, but it is, as Mr. Updike says, "friendly to the eye," and it has the invaluable quality of being as nearly fool-proof as printing type may be. The appearance of the Caslon letter in 1726 was an event, wrote T. B. Reed, the historian of English typefounding, "marking a distinct turning-point in . . . English typography, which from that time forward entered on a course of brilliant regeneration." [2]

It was this world of a freshening interest in typographical execution that Franklin entered when he reached London in December, 1724. His first employer, Samuel Palmer, was probably then at work upon his history and manual of printing; his second, John Watts, had recently helped young

[1] Bigmore & Wyman, "A Bibliography of Printing," II, 109–110.

[2] I have always supposed, in common with most writers on typography, that the earliest appearance in print of Caslon roman was in the form of the English, or fourteen point, letters in the "Opera" of John Selden, London, 1725 and 1726, but Alfred F. Johnson of the British Museum, in "A Note on William Caslon" (*Monotype Recorder*, Vol. 35, No. 4) has disturbed our certainty in this article of faith. Mr. Johnson assures us that the Selden letter was cut by Christoffel van Dyck, and through reproductions of a page of the "Opera" and specimens of the Van Dyck and Caslon letters, gives opportunity for comparisons and conclusions. But though he has taken away from us the noble volumes of Selden as the first showing of Caslon roman, Mr. Johnson does not leave us without comfort; he gives us in place of them the notes in pica size in Bowyer's edition of Anacreon, 1724, and the pica in which is printed that same publisher's "Reliquae Baxterianiae" of 1726.

William Caslon set up his type foundry, and in the time that Franklin was with him, must have been watching Caslon's progress, talking about his achievements, and waiting with excited expectation for the appearance of the books in which the qualities of the new letter were to be manifested to the world.

Samuel Palmer was a printer of genuine ability. He, too, had encouraged Caslon, but with him book design, that is, the layout of pages, spacing, leading, color of letterpress, and evenness of impression, was a matter of equal interest with the design of the type face employed in the volume. One of Palmer's productions, well known to students of Franklin's life for more than one reason, was the third edition of Wollaston's "Religion of Nature Delineated," issued in the year 1725.[3] Set in one of the pre-Caslon faces, this book is a successful production for its generation. Palmer laid out his quarto volume in a style reminiscent of the better French printing of the day, though in saying this one need not suggest that the printer had a French model in view when designing his book. There were other English works of the period in which this influence was perceptible, and nothing is more dangerous than specific claims of typographic influence. But whatever its origin, the Wollaston book, not a notable production, was yet a decently produced volume in which a printer then at work on the compilation of a typographic manual was putting into effect in his own practice the concept of openly spaced lines, well-leaded but substantial pages, balanced headings, a dignified use of ornament, and an open but strong title-page display. In the text pages of the resulting book the type is too small for the page area, and the color of the ink is not so positive as it should be, though the impression upon the page is even and uniform in tone throughout the volume. This was a skillfully made book for an English press of 1725, and a better production by far than Franklin had seen from an American press. And from its

[3] Franklin says in the Autobiography that it was the second edition of Wollaston he was employed upon in Palmer's shop, but Paul Leicester Ford, "Franklin Bibliography," No. 5, asserts that the second edition was published before Franklin's arrival in England on December 24, 1724, and suggests that it must have been the third edition of 1725 for which our young journeyman set type.

printing in Palmer's shop he must have learned much because he had been himself one of the compositors who set the book in type. From it and other books he worked upon for Palmer, he may have acquired that touch of conscious artistry which, imposed upon his natural mechanical ability, gave grace and dignity and the quality of thoughtfulness to the work which he later produced under his own name in Philadelphia. The Autobiography tells us none of this except the actual fact of its author's employment upon the composition of Wollaston's "Religion of Nature Delineated," and it would not have told us that much but for a precocious concern with the subject matter of that treatise which led the young compositor to write and publish a metaphysical reply to its argument. Franklin does not say unequivocally that he himself set in type that "erratum" of his youth, the "Dissertation on Liberty and Necessity, Pleasure and Pain," which came from the press in reply to Wollaston in 1725, but it is a fair assumption that the "Dissertation," in all probability the product of Palmer's establishment,[4] was composed in both senses of the word by our young printer. It is a superior bit of typography, composed in the new style of open setting and leaded pages, imposed in the relatively narrow octavo format that became almost universal in the later years of the century. Franklin's association with it, whether as printer or as the individual who commissioned its printing, marks another stage in his typographic education.

The traveller does not necessarily bring home either things or ideas from his travels. Dr. Johnson said of a celebrated traveller of his day: "I never but once heard him talk of what he had seen, and that was of a large serpent in one of the Pyramids of Egypt." In this chemistry of the mind in contact with experience the result is not predictable but it happened that to the particular combination of men and events he encountered in London, Franklin's reaction was positive. A new compound was produced in consequence.

The lucky breaks fall to the good players. How often in

[4] Typographical details, especially the employment in the "Dissertation" on page 32 of the engraved printing house interior which ornaments the title-page of the Wollaston, bear out the assumption one makes from the text of the Autobiography that the Franklin book was produced at Palmer's.

reflecting upon Franklin's life are we reminded of that homely aphorism! What affinity for excellence was it that drew this unknown lad, ignorant of London, successively to the two printing houses in which he might learn most of future usefulness, might find himself lifted immediately upon the first wave of the new spirit in English printing? Who told him to go to the James typefoundry and watch closely the steps employed in the making of type? How could he have known that at Palmer's, probably, and at Watts's, certainly, he would hear talk of the new roman letter being made by William Caslon, a letter he was afterwards to use extensively himself and to purchase for the use of his American partners and associates? These are questions that we cannot answer until we understand better the nature of genius. A simplified statement of Franklin's success in life, which, however, does not explain that success, is that he had the knack of doing the right thing at the right time. In further development of this familiar characterization of him, we must add that what seems to have been chance or accident invariably took him to the *right place* at the right time.

We must now review briefly the activities of this young journeyman printer after his return to Philadelphia and his reëmployment by Samuel Keimer in 1727. The increased value of his services to Keimer would be clear to us who read the record even if he had not impressed upon us with unction his importance to the business of his despised master. But it speaks for itself that a journeyman who could both work and teach others to work was important in that city in which the art of printing was at the moment characterless and slovenly. This journeyman possessed, he tells us, "uncommon quickness at composing," and his earlier experience as a pressman had recently been supplemented by what we might call a graduate course in the London establishment of John Watts. His visit or visits to the James foundry in London enabled him, when Keimer ran low on sorts, to contrive a mould, make use of what letters were left as puncheons, strike matrices in lead, and thus supply "in a pretty tolerable way all deficiencies." This "factotum" of Keimer's establishment could also engrave upon copper well enough to justify his employer in taking on the job of printing paper

money for the Province of New Jersey. He was able also, in connection with this job, to construct "a copperplate press for it, the first that had been seen in the country." Some of these statements require amendment. The types he cast for Keimer without precision instruments were doubtless pretty bad; his engravings have never been singled out for the praise of critics; and when he wrote that the copperplate press he "contrived" was "the first that had been seen in the country," he doubtless meant "in the vicinity." As a printer's apprentice in Boston he must have known that one Francis Dewing, from about 1716 onwards, was printing copperplate maps in that city and advertising his ability to do other copperplate printing.[5] But despite this ungenerous examination of his story (his complacency sometimes moves one to pick flaws in his assertions), it is clear enough why Keimer cherished him, and why his fellow-workman Meredith proposed a partnership with him.

One reads with mixed feelings the story of Franklin's associations with Keimer and with Meredith and his early severance of them. The eccentric Keimer was a poor printer, and a poor man of business, but he was undoubtedly a man of ideas, undeserving, I am convinced, of the contemptuous treatment he receives in the Autobiography. Meredith was one of the weaker brethren, whose subsequent history as related by Franklin and as recorded in Franklin's Account Books, was anything but edifying. Nevertheless I wish that one of those two, or, better, Andrew Bradford, had left us an account of young Ben Franklin in these years of their association. It would show us, I believe, the picture of a thruster, a go-getter, a superior youth unable to conceal his superiority, a calculating young tradesman very much unlike the benevolent philospher of later years. The possession in later life of

[5] Wroth, "Colonial Printer," 2d ed. 1938, page 285, records, from information supplied by Miss Clara Egli of the Division of Maps, Library of Congress, "A Chart of the English Plantations . . . by Captain Cyprian Southack . . . Engraved and printed by Fra. Dewing, Boston . . . 1717." At that time (1938) the only known copy of this map was in the Public Record Office, London, but since then a second copy has been discovered and is now owned by the John Carter Brown Library, Providence. Dewing was still in Boston in 1722 when there was published in that city John Bonner's *Town of Boston in New England*, "Engraven and Printed by Fra. Dewing . . ."

ten thousand a year or its equivalent did for Franklin what Becky Sharp was sure that comfortable sum would have done for her. Andrew Bradford must have loved him greatly from that day in 1729 when the young business builder got the public printing away from him by reprinting one of the slovenly Bradford jobs and distributing his own neater production to the members of Assembly for comparison. Pennsylvania deserved better printing than Bradford was executing in its behalf, so that one can heartily approve this action in the public service. But at the time of it Franklin had experienced, so far as the record shows, nothing but kindness from William and Andrew Bradford, and when, sometime later, Andrew as postmaster forbade his riders to take Franklin's newspaper for distribution, both men, Bradford the opportunistic official and Franklin the injured innocent, must have recalled with varying emotions that preliminary skirmish in the marketplace.

It was in October, 1729, that Franklin took over Keimer's newspaper, thus adding to his growing business that form of publication which every colonial printer needed to complete his happiness. Too often the result was bankruptcy, but it was anything but that in the case of Franklin's venture into newspaper production. In the same year he wrote his "Modest Enquiry into the Nature and Necessity of a Paper-Currency," and when the argument there presented led to an act of Assembly for the issuance of bills of credit, he was given as a matter of course the profitable job of printing the money. Mr. J. Bennett Nolan has recently added to the gaiety of life by calling attention to a later transaction in which Franklin was paid by the Assembly for printing an issue of paper money and, some years later, when the bills had become badly worn through use, was paid also for destroying them.[6] It is pleasant to get something going and coming. He made a special effort to please all those who needed blank forms, supplying lawyers, officials, merchants, and ship captains with, he says, "the correctest that ever appear'd among us." His appointment to the office of clerk of Assembly proved valuable to him, he informed one of his

[6] Nolan, J. Bennett. *Printer Strahan's Book Account. A Colonial Controversy*, page 32.

correspondents, as a means of securing the public business for his printing house. Mr. Nolan has calculated that in the twelve-year period 1739–1750 he received from the Assembly as clerk's fees and as payment for printing statutes and paper money the sum of £2,762 in Pennsylvania money.[7] Translated by a rough rule into terms understandable today, that sum would have been in the neighborhood of $40,000.

Very soon after the dissolution of his agreement with Meredith in 1730, Franklin began the establishment of those silent partnerships in other colonies which were to contribute so greatly to the influence he established over the printing trade in British America as well as to the spread of his personal reputation throughout the country. It was a bold action, in harmony with the American spirit of business aggressiveness, or perhaps one of its keynotes, for a young man still in debt for his own plant, still fighting for place against older rivals, to broaden his base of operations by sending one of his journeymen on a partnership agreement to a distant city. When Thomas Whitemarsh, the individual in question, died soon after arrival in South Carolina, Franklin saved the situation by promptly sending to fill his place another of his journeymen, Lewis Timothy. In July, 1743, he wrote in the first of his many letters to William Strahan, his English correspondent, that he had already three printing houses in different colonies and was planning a fourth. This meant, I believe, his own establishment in Philadelphia, that of the Timothys in Charleston, South Carolina, and the New York office of James Parker, then little more than a year old. In later years he sent, first, Thomas Smith and, later, his own nephew, Benjamin Mecom, to Antigua, and another nephew, James Franklin, Jr., to join his mother, the Widow Ann Franklin, in carrying on Brother James's business in Newport. Still later, according to a letter of 1785, he established Holland and Miller at Lancaster, and Dunlap and Hall in Philadelphia. His relationship with Jonas Green of Annapolis, another of his journeymen, and with William Parks of Williamsburg does not seem to have been formally that of partner, but to these and to several others even more distant

[7] Work cited in note 6, page 33.

he was banker and source of supply for materials and equipment.

It was not alone by the activities of his establishment in Philadelphia, therefore, that Franklin had come to be regarded as the leading individual in the American printing trade when he virtually gave up his active practice of it at the time of taking David Hall for partner in 1748. These associations through formal and informal partnership with printers in several colonies had been a prime means by which that situation was brought about. The business he built up in ink making and the sale of paper, as we shall see later, also contributed importantly to the attainment of leadership which continued until the firm of Franklin & Hall was dissolved in 1766. At that time his active participation in the concerns of his Philadelphia shop was but a memory.

This is a bare outline of Franklin's active career as printer. Stated in these terms it might be regarded as the career of any vigorous, enterprising craftsman and man of business. To learn its distinctive features, we shall have to discuss separately certain of his special interests and activities.

THE PENNSYLVANIA GAZETTE.

The Pennsylvania Gazette differed from the normal newspaper of its time only in having for its printer, publisher, and editor a publicist who had deliberately trained himself in polemics. The consequence was that the quality of the *Gazette* articles on local politics was such as to give it a special interest among colonial American journals. For the rest—general content, typographical style, exchange matter, and character of advertisements—it belongs in that group of admirable weeklies published by William Parks in Williamsburg, Jonas Green in Annapolis, and William Goddard in Providence, Philadelphia, and Baltimore. The *Gazette* was one of the best, and there is good reason to believe that few could equal it in circulation. We have no direct statement from Franklin as to the size of his subscription list, though there exists a letter from him to Strahan, written in 1785, in which he says, "I shall have an old account to settle then with the family of our friend Hall. . . . It was the value of a

copyright in an established newspaper, of each of which from eight to ten thousand were printed." [8]

This figure seems large for the time and the conditions of publication. Reflecting upon it, one begins to ask whether Franklin's statement really means that the weekly circulation of the *Gazette*, over a period of years, attained this average of 9,000 copies. If we assume that fact to be true and arbitrarily, and generously, perhaps, fix upon 2,000 copies as the number sent to subscribers outside the city,[9] we shall still have a weekly Philadelphia circulation of 7,000 copies. That circulation seems incredibly large for a city of which the population in the decade 1750–1760 ran from seventeen to twenty-four thousand persons,[10] or, roughly, a city of 4,000 families. The normal family contents itself with a single copy of a newspaper, but if we take Franklin's statement as meaning what it seems to say, each Philadelphia family of that decade took in $1\frac{3}{4}$ copies of the *Gazette*. We may, indeed, say that each family took in two papers, because some of the 4,000 were illiterate and a good number of them spoke no language but German. Furthermore, one asks, if each family was supplied with two *Gazettes*, what market remained for the *Pennsylvania Journal*, the newspaper which, under William Bradford the younger, continued to thrive throughout this period?

When we examine the statement of accounts of the Franklin and Hall partnership [11] for the whole eighteen-year period of its existence, we are able to segregate the sum of £13,500, or £750 a year, received from subscriptions to the *Gazette*. At ten shillings each this means an average for the period of 1,500 paid subscriptions a year. Adding to these the copies

[8] Franklin to Strahan, March 5, 1785 ("Life and Writings," Smyth edition, ix: 290–291.)

[9] Twenty-five per cent. of the edition or thereabouts seems a reasonable proportion of out-of-town subscriptions.

[10] The population figures here given were compiled by Professor Carl Bridenbaugh of Brown University from the Proud Manuscripts in the Historical Society of Pennsylvania, the Du Simitière Scraps in the Library Company of Philadelphia, and the *Pennsylvania Journal* for January 18, 1770.

[11] Original manuscript of James Parker's statement of the Franklin & Hall accounts, at the time of the dissolution of the partnership, is in the Historical Society of Pennsylvania. A photostat copy is in the John Carter Brown Library.

sent out as exchanges and to advertisers, it seems probable that the actual number printed each week would have been from 1,600 to 1,700 copies. In view of the circumstances outlined in the foregoing paragraph this seems a more likely figure than the eight to ten thousand of which Franklin spoke in his letter of 1785. If Franklin's figure were correct we should expect to find that the *Gazette* subscriptions for eighteen years amounted to something like £80,000. Actually that sum is nearly three times the gross cash receipts of the firm from all elements of its business for the whole of that period.

The newspaper subscription lists of those days of small populations and large proportions of illiteracy were normally small. Writing to Franklin in 1747, Jonas Green, of Annapolis, mentioned that he had about 540 paid subscriptions for his *Maryland Gazette*. It was thought auspicious that in 1767 William Goddard could begin his *Pennsylvania Chronicle* with 700 subscribers. In 1774 James Rivington announced a weekly impression of 3,600 copies of his *New-York Gazetteer*, adding that this was "a number far beyond the most sanguine expectations of the Printer's warmest friends; as the presses of very few, if any of his brethren, including those in Great Britain, exceed it."[12] These reflections upon Franklin's statement seem to suggest the probability that another interpretation exists for it than the obvious one that his *Gazette* circulated to the pleasant tune of eight to ten thousand copies weekly. That was certainly not the case if, as I believe, the Franklin & Hall Partnership Account included the whole business of the firm in that period 1748–1765. Isaiah Thomas asserted that according to information he had received, Franklin customarily drew £1,000 currency a year from the firm.[13] Actually the accounts show that his income from the firm was £800 currency a year, but the hearsay figure and the actual figure are close enough to suggest that

[12] Jonas Green to Franklin, July 5, 1747, "Calendar of the Franklin Papers in the American Philosophical Society," I: 3; Thomas Wharton to Franklin, February 7, 1767, "Calendar . . ." I: 69, gives the Goddard figure here cited; the Rivington statement is found in Stokes, "Iconography of Manhattan Island," IV: 836. My attention was called to the Rivington figure by Professor Carl Bridenbaugh of Brown University.

[13] Thomas, "History of Printing," 2d ed. 1874, I: 235.

the Partnership Account was a statement in full of the firm's affairs. If the *Gazette* had circulated 9,000 copies a week for any considerable part of the period 1748–1765, that Account would have told a very different story in such items as paper consumption and subscriptions to the *Gazette*, and in the figures which make up its totals.

INK MAKING.

It must be remembered, however, that neither Franklin's income nor his influence upon the printing trade of the country were based wholly upon the *Gazette* and the other business of the printing house. Realizing from experience the difficulties that faced the American printer in maintaining a supply of ink and paper, the essential articles of his commerce, he lost little time in entering the business of ink making and in becoming an agent of the Pennsylvania paper mills, thereby planning to ensure his own peace of mind and to give comfort to other printers throughout the colonies. On March 21, 1733, as his first step in this direction, he purchased a lampblack manufactory from Nathaniel Jenkins.[14] Lampblack mixed with varnish, that is, linseed oil thickened by boiling, forms the black, viscid substance we know as printers' ink. About six weeks after his purchase of the lampblack house from Jenkins, Franklin advertised in the *Gazette* his ability to supply very good lampblack. One of the earliest reports of the industrial possibilities of Pennsylvania informs us that linen, made from flax, was being manufactured at Germantown in 1692, and from a later source we learn that in 1729 Pennsylvania exported 1,800 bushels of flaxseed, or linseed, to Scotland and Ireland. An oil mill was erected in the colony as early as 1691. There was, therefore, no lack of the raw materials that went into the making of printers' ink when Franklin took up the business of selling it and of manufacturing one of its constituents. In 1735 he is found

[14] Eddy, "Account Books Kept by Benjamin Franklin, 1728–1739," 1928, page 45. Andrew Bradford also had been interested in lampblack. As early as 1721 he asked the Pennsylvania Assembly to give him a monopoly of its production and sale. Mr. Nelson B. Gaskill has called my attention to the fact that even earlier than this, in 1712, a five-year monopoly in lampblack had been granted John Parmyter by the Assembly of New York.

selling printers' ink to the celebrated firm of Kneeland & Green of Boston, and thereafter, for years, he sold to printers, north and south of Pennsylvania, quantities of lampblack and varnish, or ready-mixed printers' ink in keg or canister. Nowhere do we learn the source of his supply of varnish. The boiling of the oil was a disagreeable job, attended with some danger of setting fire to the house in which it was done. He does not tell us that this unpleasant task was among his personal activities, but his accounts make it clear that he was in the business of selling the product of it.

But a little bit of printers' ink goes a long way, and one doubts that with his limited market, he expected to make much money from the sale of ink to his brother printers. But one does not doubt that his ability to supply this essential of their business was among the factors that made him indispensable to them, kept them upon his books, and encouraged them to buy from him the paper which he was soon in a position to supply.

RAG MAN AND PAPER MERCHANT.

In his participation in the paper business, Franklin once more approached the problem of money making from a sound point of vantage, that of supplying the manufacturers with their essential raw material. About 1734 he began that business of exchanging old linen rags for new paper which became one of his most profitable and most useful activities. His consignments of rags to Pennsylvania papermakers, at the rate of a shilling half-penny a pound for the better quality, ran in the period 1735–1741 to nearly 75,000 pounds, or thirty-seven tons in weight. In the period 1741–1747, he sold 11,000 pounds of rags to William Parks of Williamsburg alone, and in that period and the next ten years he sold to the Pennsylvania mills more than 166,000 pounds.[15] This service was of the utmost value to the papermakers, especially as our rag merchant seems to have been willing to accept from them payment in kind, taking paper of all sorts which he used either in his own printing house or sold for cash to the printers with whom he was in correspondence in several colonies. The

[15] Work cited in note 14, page 30. Also Eddy, "Account Books Kept by Benjamin Franklin," 1739–1747, pages 16–35, 98–99.

purchasing of the rags was one of the duties of Mrs. Franklin. It was probably her job also to pick and sort them.

After analyzing Franklin's accounts with papermakers, Mr. George Simpson Eddy wrote that in his belief "no one else in the Colonies, between 1739 and 1757, dealt so largely in paper" as did the industrious rag collector of Philadelphia.

It is not merely as a source of wealth to Franklin that we contemplate his long years of bartering with the Pennsylvania papermakers. In a letter of 1771 to Humphrey Marshall, he wrote: "I was the more pleased to see in your letter the improvement of our paper, having had a principal share in establishing that manufacture among us many years ago, by the encouragement I gave it." Years later Brissot de Warville wrote, "Dr. Franklin told me that he had established about 18 paper mills." [16] One of these statements, at least, requires clarification. Papermaking was established in Pennsylvania in 1690, a good many years before Franklin was born, and a mill was being set up in New England in 1729 at a time when his chief concern was to get the newly established printing firm of Franklin & Meredith on its feet. Papermaking, therefore, was an established industry in Pennsylvania and New England before Franklin engaged in it, and his use of the word "establishing" in the letter to Humphrey Marshall was intended in the sense of "expanding." There is no question that his activities as a collector of rags for the papermakers provided a stimulus to their business and that through them he splendidly served himself, his craft, and his nation. Regarding the extent of his service to himself one wonders whether his papermaking trade was not as great a factor in the financial ease of his later life as the *Gazette* and the printing house.

THE AMATEUR OF TYPE.

We have seen that Franklin observed the processes of typefounding so closely in London that upon his return to Philadelphia he was able to make up deficiencies in Keimer's fonts by a crude casting of sorts. This interest in type and the making of type stayed with him until the end, though we hear no more of it for some years. But in the year 1744, or

[16] Work last cited, page 16.

earlier, his interest in typefounding seems to have revived. In that year we find him ordering from Caslon, through Strahan, a font of English.[17] This was a normal procedure. Because there were no type foundries in the colonies, all American printers of the time must secure their type from Europe. But it was not to be expected that Franklin would sit quietly under this necessity if he could devise a way to remove the burden of importation from himself and his countrymen. Earlier in the same month, he had thanked Strahan for his "care and pains in procuring me the founding tools; though I think, with you, that the workmen have not been at all bashful in making their bills." These in all probability, were the first typefounding tools to come to any part of America north of Mexico. They enter history on the fourth of July, 1744, and so far as any direct information about them is concerned, they leave it on the same day. Franklin never mentions them again, and it is certain that he continued to order from British founders whenever he needed new type for himself or for any of the journeymen he set up in business. Though he sold a certain amount of type to his associates, there are no entries in his account books which indicate that he was selling them type of his own casting. It is clear that whatever his fortune with this experiment may have been it was not so notably successful as to lead him to mention it in the Autobiography, or to recall it, so far as I have discovered, in any one of his many letters on typographical subjects. But from another source than Franklin's own words there comes a suggestion that these founding tools were not cast aside as soon as received as an unwise purchase. Gustav Mori, writing in the *Gutenberg-Jahrbuch* for 1934, declares on the authority of the elder Christopher Sauer that about the year 1747 Franklin offered the printers of the Ephrata Monastery certain articles of typefounding equipment, without matrices, for a specified sum, and demanded a similar sum to teach them to make matrices of lead and to cast type therefrom. Mr. Mori goes on to say that the good brothers de-

[17] In this letter Franklin does not specify by name the founder for the 300 lbs. weight of "good new English letter," which he ordered, but in a letter dated February 12, 1744, which internal evidence suggests should be 1744–45, he writes "I hope Caslon will not delay casting the English Fount I wrote to you for . . ."

clared in the colophon of one of the books from the monastery press that the volume had been printed from type of their own casting, and from this assertion he assumed that, as proposed, the Ephrata brothers had been instructed in typefounding by Franklin. Unfortunately these statements are not documented by their author, and in the absence of record of any Ephrata book bearing a colophon of the character described, I have concluded that when he wrote of such a work Mr. Mori was thinking of the younger Sauer's *Ein Geistliches Magazien*, one number of which (of 1771 or 1772) a colophon declares, and declares incorrectly, was printed with the first type cast in America. It stands, therefore, at this: Franklin acquired founding tools from England in 1744, and about 1747 is reported to have been negotiating the sale of certain typefounding tools to the brothers at Ephrata, and further to have offered to teach them, for a price, the art of making matrices. We can go no further than this in the absence of documents. I should not, perhaps, have brought up a matter which I am compelled to leave with you in this state, but I have always wanted to share with someone my uncertainty regarding this early venture of Franklin's into typefounding. Furthermore, the story is important in the consideration of his enduring interest in type.

It is not easy to know when Franklin first began the use of that type of William Caslon's which was so greatly to improve the general run of printing in England and America. The first mention of a purchase of Caslon type in the correspondence is in a letter to Strahan of July 31, 1744. But Caslon had begun selling to printers ten years before that date, and one would look for an earlier use of his type by a printer of Franklin's enterprise. Though I cannot boast an accurate eye for type differences, it seems to me that new type was put into the Franklin cases while the "Collection of all the Laws of Pennsylvania" of 1742 was going through the press, that, to be more specific, its pages are set in the Caslon letter from signature 5 P to the end of the volume. Furthermore the "Cato Major" of 1744 is in what I think is Caslon, and that book was printing before Franklin sent in his order of July 31 of that year. For these reasons I fix the year 1741, or thereabouts, as that of Franklin's first patronage of the

Caslon foundry. If someone more expert in the identification of type faces takes issue with me on this opinion, he will not find me making a stubborn defense of it. At any rate, Franklin's association with Caslon continued, to the advantage of American printing, for many years, though at one time an error in one of the founder's bills seemed likely to bring it to an abrupt ending. The matter was adjusted, and through Franklin the admirably clear letters of Caslon continued to effect improvement in the appearance of American printing.

It is not easy always to understand just where Franklin drew the line between business and sentiment. We do not find, for example, that he ordered for Franklin & Hall or for others of his American associates any of the type of John Baskerville, yet his admiration for Baskerville's product was of the highest. That distinguished printer and type designer brought out his earliest book, the Vergil, in 1757, the year in which Franklin went to England as colonial agent for the Province of Pennsylvania. One of his first actions upon arrival in England was to subscribe for six copies of the Vergil, and when in 1758 Baskerville was bringing out his Milton, Franklin subscribed for that work also and wrote to Isaac Norris in Philadelphia, "I have inserted your name in his List of Subscribers, as you mention your Inclination to encourage so deserving an Artist." In 1760 he wrote the Birmingham founder of the trick he had played upon one of the detractors of the new type face, mischievously, he says, showing him as Baskerville letters the upper part of a Caslon specimen and listening with glee while the amateur critic of types (there were many of us even in those days) inveighed against the blinding qualities of the new design. The association with this distinguished printer and founder evidently continued, for, years later, in 1773, Baskerville wrote Franklin that he was enlarging his foundry in order to sell types abroad, especially to the colonies. He begged Franklin's good offices in helping him sell his fonts to printers in North America. But Baskerville's hopes proved abortive. Even with Franklin's good will to help him, he did not sell much type to American printers. The American printer in general was a conservative; it had taken him a long time to realize that Caslon was better than James and he had no intention of

changing again in favor of the upstart who now sought his custom.

Though he had retired from active printing as early as 1748, Franklin's interest in the problems of typography continued to the end of his life. For a long period we read in his correspondence little of printing matters, but events in a world which included the Fourniers, the Didots, and the Anissons led him in his French sojourn to a revival of interest in printing and to an actual resumption of its practice. My belief is that he set up a private press and type foundry in his house at Passy as a relief from the vexations of his daily life. He knew exciting moments in plenty in the course of that mission to France, but there was a great deal of routine in it of a tiresome nature. Replying to cadets of good family who had no money but wished to enter the American army at ranks considerably in advance of those they held in the French establishment was enough in itself to compel a search for relaxation. It is interesting, I think, that in this need the old man fell back upon the craft he had learned in boyhood. There at Passy, with a French press and types, and probably with a French journeyman to help, he printed for his friends a group of frivolous little pieces, a few serious ones, and many blank forms for the use of his office. One can be sure of the interest and delight with which he learned and accustomed himself to the French style of setting and page design.

The press which Franklin established at Passy was, however, more than a toy and a diversion. Through its operation he encountered again, this time as an experimenter, the problems of type design and press construction, and once more circumstances lead us to remark upon his knack of being at the right place at the right time. The tendency towards "modern face" in type design had begun in France as long ago as 1702 with the letters of Grandjean. Further developed by Pierre Simon Fournier, the new style, in Franklin's time in France, was claiming much of the thought of Firmin Didot. Some years before, Fournier had devised the point system for the measurement of type and had written his "Manuel Typographique." At this very time, Anisson and Didot were making presses with platens large enough to permit

an entire type form to be impressed with one pull of the bar, thus cutting down appreciably the time and effort of press-work. Into all this activity, preliminary to the great changes in typographical practice that occurred in the generation after his death, Franklin entered with zest, corresponding with different members of the Fournier and Didot families and with others interested in typecasting; reading a work on logographic casting, the "Nouveau Système Typographique" of Madame de Saint Paul; experimenting himself with the making of logotypes; and corresponding with Anisson *fils* on that subject and on improvements in the press.

But he was not satisfied in this instance with talk. He bought typefounding equipment, and in his house at Passy cast quantities of type, some of which he afterwards sold in America.[18] In this time also he caused his grandson, Benjamin Franklin Bache, to be taught the mysteries of printing and typefounding by the Didots and the Fourniers. In 1785 he brought young Bache back to Philadelphia, equipped with a foundry and prepared to cast type for all who would buy. These were wonderful years for Franklin, the typographer, but for a greater effect upon the history of printing, they should have come earlier in his life.

A BRIEF ANALYSIS OF THE PRINTING BUSINESS.

It is of interest to consider for a moment the character of the printed matter which issued from the Franklin establishment in Philadelphia. Neither with Franklin alone as proprietor nor as the firm of Franklin & Hall was its accomplishment such as to justify us in claiming for it a great degree of influence upon the cultural life of its community. Franklin was an assiduous reader of books, a self-educated man enthusiastic in the cause of practical culture, and the founder of a library and a learned society, but even with this predilection he was not a publisher of books on anything like the scale one might expect. It would not occur to the historian to apply to him the epithet "Nurse of Literature," which seems to belong to his contemporary William Parks of Annapolis and Williamsburg. His bookshop, Mr. Van Doren has

[18] Livingston, "Franklin and his Press at Passy," Chapter VI. "The Passy Types in America."

pointed out, served the literary interests of Philadelphia, and in the other ways just specified his activities made him a leader in the intellectual progress of his community. It seems clear, however, that he regarded his printing house as solely for utilitarian service, and that he had no intention of jeopardizing its prosperity by going into the business of publishing on his own account. It is something of a disappointment to learn that, with all his interest in the subject, he published no works of science except the Pennsylvanian Fireplace book and a few books of household medicine. It is difficult to understand why he never printed in his own establishment some record of those fundamental experiments in electricity which he and his group of Philadelphia associates carried out from 1746 onwards. He was not alone among American printers in his indifference to the honor of publishing books of science and letters. He and they realized, probably, that, except within certain narrow categories, there was little sale for the book published with an American imprint. The imported book was the thing. Inventories of colonial libraries, north and south, are heavy with titles of British production; rarely does an American-printed work appear upon them. Locally printed books either were not given place on the library shelves beside the London production, or were regarded by owners and estate appraisers as ephemeral material of a value too small to justify their inclusion in the inventories. Franklin was not quixotic enough to tilt at this particular windmill of custom and fashion.

This is not to say that Franklin failed to engage in publishing ventures of any sort. The *Gazette* was one of those he fostered; the Poor Richard Almanac was another. I have found no figures for the early years of Poor Richard, but in the period of the Franklin & Hall partnership measured by the years 1752–1765, the average annual impression of that homely production was something over 10,000 copies, sold at 4d. each. But we may not pause for too close an analysis of the firm's accounts.[19] Turning to the statement of cash receipts for 1748–1765, we find the total to be £28,266 Pennsylvania currency, or about $416,000 in today's money. The

[19] The figures quoted here are drawn from the important document cited in note 11, above.

proceeds from the *Gazette* account for more than half this sum. Then in order come the job work, Poor Richard, and the public work. The amount received from the sale of primers, catechisms, spelling books, Votes, Laws, and Indian treaties, respectable in the aggregate, was relatively small under the head of each category. One item "Books & Pamphlets, printed and sold in the shop" ran to £1,118 Pennsylvania currency. Analyzing the account in a different way, we find that the public work and the job printing brought in £6,314 Pennsylvania currency, the *Gazette* subscriptions and advertising £17,000, Poor Richard and the lesser categories some £5,000. A summarized statement of the partnership account informs us that about 61 per cent. of the firm's income was from the *Gazette*, 21 per cent. from the public work and job printing, and 18 per cent. from miscellaneous publishing projects at its own risk. If figures were available for the period in which Franklin was alone, I believe the proportions would not be greatly different.

FRANKLIN AS TYPOGRAPHER.

Comparing the printing done by Franklin in his early years as a master printer with contemporary work executed in Boston, New York and Philadelphia, it is obvious that the revival of interest in the esthetics of printing which he had encountered in England in 1725 and 1726 had affected permanently his own attitude towards his craft. There is no doubt that thenceforth he attempted consciously to produce work that would be pleasing in typographical form, kind to the reader's eyesight, and a correct presentation of the author's text. It must always be remembered that this revival was not based upon new type designs or new implements, but upon a new thoughtfulness in the use of the available types and equipment. An appreciation of correct spacing and leading of letterpress, of evenness of presswork, symmetry and balance of page design, the reduction and symmetrical distribution of the wording of title-pages were all factors that the English printers were giving renewed attention to before Caslon produced his mechanically uniform type faces. All these were characteristics of an age that sought clarity, balance, and ease in the forms of its art as well as in its intellectual processes.

Franklin was not an innovator in typographical design. One of his few excursions from the well-beaten path was his "Cato Major" of 1744, but I have never felt that this book was as successful as the general run of his government publications, and the style of these was an inheritance from the seventeenth century. Until he began printing at Passy under the French influence he never for long got away from that form of title-page in which a rather narrow rectangle of display matter was enclosed within ruled borders. But working within this limitation dictated by his conservatism he created a variant upon the earlier style which became the norm for American printers. Instead of attempting in the old manner to crowd his title-page with a complete synopsis of the text, he stripped its wording to the barest statement of the matter of the book and, by taking thought, displayed this concise statement in such fashion that each word had its own place and its own weight in the design. His pages of letterpress were set upon the paper page with proper regard for margins, and composed with a spacing and leading consciously intended to make easy reading without the sacrifice of solidity and color. Economical of paper, he and his successors for generations employed in the text setting a type size somewhat small for the page size. The need for paper economy prevented in these American printers the ease and generosity, the lavishness which demand admiration when one examines the work of the great printers at the end of the century—Baskerville, Bodoni, and Didot. There is, in consequence, always a feeling of frustration when one finds the monumental title-page of Franklin, and those contemporaries who learned from him, followed by pages of text correctly designed but executed in a type too small for the area covered. But within that limitation imposed by the need for paper economy Franklin at his best, as in the Indian Treaties (I like especially his first, the Treaty of 1737), and in his books of Pennsylvania statutes (I like the "Collection of all the Laws" of 1742), gave his patrons a book that pleased their critical sense and was easy to read. At the same time, and through the agency of such books as these, he provided contemporary printers with models which they might follow, not by a large expendi-

ture for new equipment, but merely by taking thought of what they were doing.

It is my belief that Franklin allowed himself to be satisfied when he had achieved this standard of excellence. He was interested in printing as a means of earning a living, not as a means of artistic expression. He believed that to earn his living honestly he must give a good job to his customers, give them printing they could read with ease and look at with pleasure. He never went beyond the necessary in practical matters, and his typographical style, once set in a good mould, made no further progress. But his competency had results that reached beyond the doors of his own shop. He was a better teacher of printers than printer. His apprentice and journeyman James Parker learned from him the fundamental principles of the art and carried them on to a finer eventuation. The "Charter of the College of New York" which Parker printed in 1754 is strictly in the style I have described as characteristic of Franklin, but the matter of the ruled title-pages is so admirably placed and the composition and presswork have such a degree of brilliancy, convey so impressively the sense of having uttered the last word in that particular form, that any work of Franklin's I have seen is of an inferior order to them. Jonas Green worked for Franklin, learned from him the integrity of type, and went on to produce his "Laws of Maryland" of 1765, a book which has the honesty, symmetry, and balance of Franklin's work rendered distinguished by a sort of freedom and boldness, a generosity, not found in the work of the master. One thing we are prone to forget is that Franklin's interest in printing as a practice was dormant from the day of his partnership with David Hall in 1748 until he took it up again as an experimental hobby conducted in his own house at Passy in the period 1779–1785. Hall carried on the Franklin style without change, except a change for the worse in presswork, until 1766. The imprint Franklin & Hall, therefore, means Franklin's style of 1730 and Hall's inferior workmanship. We shall never know what Franklin's skill would have become if he had continued at work after 1748, if he had been active in the practice of typography when Baskerville was giving a new quality to the printed word, and when throughout Europe

the ferment of experiment was working in the printing shops and the type foundries. But long before that day he had become so absorbed by philosophic, scientific, and political ideas that his trade became a matter of secondary interest in his life. Comparing Bradford's "Laws of Pennsylvania" or B. Green's "Acts and Laws" of Massachusetts, both of 1714, or B. Green's Indian Treaties of 1726, 1732, and 1735, or Kneeland & Green's "Acts and Laws" of Massachusetts of 1742 with Franklin's Treaty of 1737 or his "Collection of all the Laws" of 1742, we think of him as having established in his country an admirable standard of printing. Having achieved that standard, he passed on his taste, good sense, and skill to others more interested than he in carrying their art to higher levels.

There must always remain a feeling of disappointment among those who love the craft of printing that the most distinguished figure in the history of American typography has no place among the inventors responsible for the technical progress of the art. When in 1743 Cadwallader Colden described to Franklin his ideas upon a process which must have been a form of stereotyping, one wonders why with all his mechanical ingenuity, his industry, his passion for new ideas, he did not make Colden's proposed method effective. He probably knew of Ged's previous invention, and he certainly realized that the printing trade in America was in no need of a process visualized at that time chiefly as a means in the production of large editions for which type was to be kept standing. But even so, why didn't he get excited about it just as an idea? Probably the answer lies in his natural pragmatism; the American printing trade had little need in that day of the stereotype process. In later years, when that need arose, he or another would find time to satisfy it. Sufficient to the day are the implements thereof, is a concept that might be regarded as a tenet of Franklin's philosophy.

And so with other aspects of his interest in press and type. As early as 1753, he made an admirable suggestion for the increase of ease in running the carriage of the press back and forth,[30] and there is reason to believe that he built a press or

[30] Franklin to Strahan, October 27, 1753 ("Life and Writings," Smyth edition, III: 165–167).

presses embodying this improvement for his printing-house at Passy.[21] Neither at one time nor the other, however, did he force that idea upon the world by constructing presses which printers would have been compelled to buy because of the improved mechanism of their carriages. It remained for another man of science, William Nicholson, to make in the year of Franklin's death the fundamental change from the vertical principle of impression to the horizontal, and thereby to give the world the cylinder press. He bought typefounding tools, he was an early patron of Caslon, a staunch supporter of Baskerville, and a patron of the Fourniers and Didots, but so far as we know he designed no type and made no improvements in the mechanism of its production. He had more to do with the paper trade than any man in America, but it was after his death that the Fourdrinier papermaking machine came into being.

It was greatly to our advantage, of course, that he should have given up reflection upon the printing processes to talk and write and cogitate upon problems that had to do with the happiness of man. It was essential that printing should be carried beyond the primitive stage in which he found and left it, but it was not necessary that this advance be brought about by him. His interests were fundamental, universal. The world just then needed Franklin the scientist and practical political philosopher, and his country needed the man who could stand before the House of Commons and by sheer sense and good temper encourage it to reconsider the Stamp Act. When we complain that his name is absent from the roll of those who have changed the aspect of his beloved craft, his silence replies in terms that seem to mean: "It is more fitting at this time to discourse of men and states, to build better chimneys, and to fly kites."

[21] Livingston, "Franklin and his Press at Passy," page 124.

AERONAUTICAL RESEARCH.*

BY

JEROME CLARKE HUNSAKER.

I welcome this opportunity to speak of aeronautical research because just now relatively few people are concerned with it.

Our resources are being strained to the utmost to produce aircraft now in immense numbers. While it is undoubtedly true that an airplane now is worth more than ten airplanes next year, it is no less true that a good airplane now may not be good enough next year.

Research is primarily concerned with finding out how to get better airplanes next year. They certainly can be better. Depending on the vigor and imagination applied in research, we have a chance to develop airplanes and their armament and equipment superior to those the enemy will bring against us.

Mass production implies standardization and the freezing of designs that were available when the program was adopted. Since adherence to a program naturally appeals to the vast number of workers and tax payers, politically minded officials, having responsibility for it, will shy away from any thought of change.

However, the enemy will not be so obliging as to continue his attack on us with his present methods and weapons. Nor will he be so obliging as to wait for us to perfect new and better ways to defeat him.

Since the start of active warfare in Europe, the Germans have raised the engine power, the speed and the ceiling of their airplanes. At the same time, fire power, armor and other protection have been notably increased. There is evidence of standardization but on a term basis, with new models appearing at intervals.

The British, largely as a result of continuing research and

* Read at the Medal Day Meeting, Wednesday, April 15, 1942.

experiment, have met the improved German airplanes with improved British models. But some changes of a drastic nature had to be made as a result of bitter experience.

Last year many exported American airplanes had also to be radically altered as a result of British combat experience. No doubt further interference with orderly production schedules will occur. It is the enemy who forces changes and determines when our airplanes are obsolete.

Many changes do not result from research, but rather from the lack of it; or from lack of foresight of what the enemy can and will do. When military necessity requires immediate action, production men are made unhappy, paper production schedules are upset and there is gross waste of effort and materials. War is essentially wasteful.

To minimize such production upsets is the joint responsibility of research men, aircraft designers and the military services. There must be strict control of design by the fighting services, while at the same time the research laboratories must have early notice of future tactical requirements.

For example, if there be forecast a demand for night fighting, a number of research problems are at once indicated, such as suppression of exhaust flames, problems of night vision, special detection and navigational equipment to assist interception of an enemy in the night sky. A new requirement sets many research groups to work.

Another example might be a demand for fighting at very much higher altitudes. Here a whole array of difficult problems are thrown to the research laboratories. First, there must be improved supercharging of the engine to give lively performance at higher altitude.

Also, the pilot must be protected against the effects of low pressure and temperature and lack of oxygen. Here the physiologist and the airplane designer must collaborate.

Such research problems require time. But there is never time if the problems have not been foreseen. Perhaps our own demands can be foreseen, but problems of painful urgency result from disclosure of the enemy's superiority.

There are also problems of a fundamental nature that are not of immediate interest to the fighting services and of no interest at all to production men. Such long-range research

is most difficult to handle in war time, because of the overwhelming pressure for immediate results. Short-range problems are also more readily solved, and research men are human enough to pitch in with greater enthusiasm where tangible results are in sight.

However, research that discloses new knowledge and clarifies obscure physical phenomena may lead to revolutionary changes in the art, and to inventions of the highest importance. Fundamental discoveries are unpredicatable both as to their nature and as to the time of their appearance, but we cannot afford to give the enemy a clear field. Total war employs all aspects of scientific research.

It is not so long ago that fundamental studies of the combustion process in an engine cylinder resulted in a better concept of the phenomenon known as knocking or detonation, and to Thomas Midgely's invention of tetra ethyl lead to control it. Further research now enables the oil industry to supply superior fuel of high anti knock quality, to operate in modern high compression engines.

Research on the aerodynamics of flow separation resulted in a design for cowling airplane engines that cut the drag 75 per cent and made commercial air transport and modern long-range bombers practical. More recent aerodynamic research has resulted in wing and propeller forms that permit much higher speeds.

During the last war, fundamental research was largely interrupted in favor of immediate problems, with the notable exception of a small group at Göttingen University in Germany. Their research could hardly have appealed either to the military mind or to industrial leaders. It dealt with the mathematical theory of potential flow in an idealized frictionless medium and with the nature of vortex motion. It was an academic effort to explain how and why an airplane wing achieves its lift. From these studies, about which we learned only after the war, came applications of great practical importance. Although German airplanes did not win that war, they frequently forced the pace.

An example of a radical change in the art resulting from a fundamental discovery is to be found in the hardened aluminum alloy, named duralumin. Our first knowledge that the

enemy possessed a superior light metal came during the war in 1916 from examination of a wrecked Zeppelin. By 1918 German airplanes were made of this metal. Now it is practically the universal standard, and a vast aluminum production is a military necessity.

In Norway the interruption of weather reports from the North Atlantic destroyed the conventional basis for European weather forecasting, which traditionally depended on the compilation of weather data from the west. Professor Bjerknes and his collaborators in Bergen developed a physical theory of weather sequence based on the identification of masses of moving air by means of high altitude soundings. This so-called polar-front theory solved a problem for Norwegian fishermen and revolutionized meteorology.

No one can know whether the enemy has found one of those fruitful paths of research that lead to revolutionary changes. But we certainly should compete with him in the search for it.

The prospect should be excellent for prompt utilization of the results of research in aeronautics since the American aeronautical industry has always been based on flexible production methods. After its enormous expansion in productive capacity by marriage with the automobile industry, this flexibility must not be lost. When the automobile industry produced a standardized article with a yearly model change, the retooling took a full twelve months. This is too long. The aeronautical industry works, not by a model or style year, but by a series of releases. When a design is first adopted, a definite number of planes are released for production. When sufficient improvements have been perfected, a further release is made, and so on. Thus there is continuous improvement of a product without interruption of production.

We must manage to incorporate our research results into our production in order to have both good airplanes now and better ones next year. Sustained research is an insurance that our airplanes can be individually superior to those of the enemy, and we surely can depend on American industry to produce them in superior quantity. Victory should follow from the quality and the quantity of these instruments of Air Power.

THE PRECIPITATION-HARDENING OF METALS.*

BY

PAUL D. MERICA.

The art of metallurgy has been greatly fortunate in its early acquisition of the practice of heat-treating steel, since without hardened steel tools and other vital machine parts our industrial development must have been substantially restricted or retarded.

On the other hand, the science of metallurgy may not have been equally fortunate in this same acquisition, at least in one respect. In the thermal- or quench-hardening of steel, it was confronted in its very infancy with a physical phenomenon, both unique and of most complex and puzzling nature; so difficult and varied in character indeed, that for half a century it has constituted a major problem and focus of interest for metallurgists, both practical and theoretical. But the strenuous experience and activity of grappling with this particular problem has undoubtedly been largely responsible for blinding metallurgical science for many years to the existence of a much simpler and quite general type of metal-hardening phenomenon, which under the name of "age-hardening," "dispersion-hardening," or "precipitation-hardening" was only in recent years discovered and elucidated.

In retrospect it now seems strange that such a simple and general phenomenon as "precipitation-hardening" should have evaded our recognition for so long. But the overpowering example of the quench-hardening of steel evidently created the unfortunate illusion that metals could be hardened, if at all, only by the simple steel treatment of heating and cooling by quenching. And experiment showed that other metals and alloys could not be so hardened—at least to any important degree. Consequently for many years there remained hidden behind our lack of understanding of a few simple matters, the existence of a really large and important

* Read at the Medal Day Meeting, Wednesday, April 15, 1942.

group of alloys which are hardenable by heat-treatment—and hardenable in substantial measure. The principal simple matters we so long failed to recognize were *first* that the hardenable alloys must be compounded by a few simple rules but *second* and more important, that a second, additional heat-treatment step must usually be added to that prescribed for steel-hardening; after the heating and quenching from a high temperature there must follow an aging or tempering treatment at some intermediate temperature. And it was somewhat baffling to find that in precipitation-hardening the quench-treatment softens the alloy instead of hardening it, as in the case of steel; and only the subsequent aging or tempering treatment hardens the alloy—again contrary to steel experience, in which tempering softens the quench-hardened steel.

And so with the guide-post of steel experience pointing in the wrong directions, precipitation-hardening alloy systems and practice were too long delayed in coming within the field of our recognition.

By good fortune, one very important age-hardening alloy finally registered itself in our experience, largely because of the accident that the second or "aging" step of the heat-treatment process did not require a higher than room temperature; even at room temperature this alloy aged and hardened spontaneously after quenching. Thus was Wilm's duralumin discovered about 1909—an alloy of aluminum containing about 5 per cent. of copper, magnesium, and other elements. The hardness and strength of this alloy could be doubled by quenching and room temperature aging, and it fairly promptly acquired practical importance as a structural, light material, particularly for dirigible construction. But metallurgically it remained a curiosity for many years and, like steel, was regarded as a unique alloy.

However freaks, in the scientific world as well as elsewhere, have a habit of exciting curiosity, and within the following decade curiosity, powerfully abetted by the necessity during World War I of harnessing duralumin better to the requirements of the times, led to the investigations of Merica, Waltenberg and Scott (published in 1919) which revealed the physical nature of the hardening process in this

alloy. From the results and conclusion of these investigations, it was also apparent that the age-hardening of duralumin was no isolated phenomenon but that it was probably a frequent potential possibility in most metals and alloys. This indeed, during the following decade or two, was found to be abundantly true.

PRECIPITATION-HARDENING RESULTS FROM A SUPPRESSED TRANSFORMATION.

Let me review for a moment the structural mechanism of precipitation-hardening.

Metals, and many alloys as well, consist of aggregates of crystals or grains of substantially homogeneous atomic lattice. Their physical properties, including hardness and strength, depend sensitively upon the inner structure of these individual grains—as well as upon the structure of their aggregate. Each grain or crystal can absorb in solid solution—namely, into the atomic lattice—varied amounts of other metals or elements, and as in the case of most chemical equilibria, the amounts of these additional elements so absorbed, vary with the temperature, being usually greater at higher temperatures than at lower ones. When a grain of metallic solid solution of this type, saturated at a high temperature—say just below its melting point,—is cooled, the solid solution becomes supersaturated with respect to the solute atoms and normally the excess solute atoms are precipitated, often in crystalline combination with atoms of the solvent lattice or with other solute atoms which may also be present. The crystal, originally of homogeneous lattice structure, becomes now duplex in structure, containing small crystallite precipitates of the second constituent or phase.

The effect of the presence of "stranger" atoms in solid solution in the "host" lattice of the metal (or alloy) is to harden and strengthen it, but this effect is usually mild when these atoms are present in the form of precipitated crystallites and the latter are readily microvisible—namely—greater than about .0001 cm. in diameter. It had been recognized that the hardening effect of such inclusions in metallic grains was greater the finer their particle size, but the impression was current that the maximum hardening effect of stranger atoms in a lattice was attained when these atoms were present in the

finest possible dispersion, namely in solid solution and in atomic dispersion.

In seeking a physical cause for the hardening of duralumin it was natural to suspect the possibility of a phase transformation suppressed by drastic cooling, since in the case of steel, only by prior suppression of the pearlite transformation can it be martensitically hardened. But aluminum suffers no such allotropic transformation as the gamma-alpha iron transformation which is suppressed in quenching steel. One had to look elsewhere!

Two important observations pointed the way. Duralumin hardened more rapidly if aged at temperatures somewhat above room temperature, although it softened if aged at still higher temperatures. The "aged" and hardened condition was evidently unstable, probably even at room temperature. This fact strongly suggested that some phase reaction must have been suppressed during quenching, which would have occurred upon slow cooling.

A curious feature of the age-hardening of duralumin had been established by Blough and his associates of the research staff of The Aluminum Company of America. The intensity of hardening increased as the temperature of the quenching treatment increased.

This suggested that any transformation of which the suppression during quenching was responsible for age-hardening, must be of a character altering with temperature. Now the precipitation of a second phase from supersaturated solid solution could be such a transformation, although hardening had not hitherto been known to be associated with such transformations. Furthermore little was then known about the metallography of the duralumin alloy, and in particular about the solubility of the additional elements copper, magnesium, and silicon in aluminum.

By following these two faithful indications, however, it was finally possible to establish these conclusions:

> *one*—that the solid solubility of copper in aluminum did vary considerably with the temperature, being about 5.5 per cent. just below the melting point of the alloy and only about 0.5 per cent. at about 200° C.;

two—that duralumin heated to about 500° C. absorbed the contained copper wholly into solid solution, but that normal precipitation during slow cooling of excess copper over about 0.5 per cent. (in the form incidentally of a compound $CuAl_2$) was actually suppressed by quenching and

three—that this excess copper precipitated gradually during aging, and presumably in the form of a host of very finely dispersed particles of $CuAl_2$ (or something closely akin to it) scarcely visible under the microscope and certainly escaping microscopic identification at the time of the early investigations;

four—that age-hardening must be due to the presence of this fine precipitate, interrupting and distorting the crystal lattice of the aluminum.

The conclusion was therefore imposed that the hardening effect of stranger atoms or inclusions in the aluminum lattice must be at a maximum, not when these atoms were in solid solution and in atomic dispersion as had hitherto been believed, but when their particle size was of some dimension intermediate between that of atoms (in linear terms about 10^{-8} cm.) and that of readily microvisible particles (about 10^{-4} cm.).

The prescription for age-hardening or precipitation-hardening aluminum was therefore obviously:

one—add a modest amount of an element whose solid solubility increases substantially with temperature, an amount greater than its solubility at aging temperatures;

two—heat the alloy to a sufficiently high temperature to absorb as much as possible of this hardening element into solid solution and cool drastically to suppress the normal precipitation from supersaturated solution;

three—age or temper the quenched alloy at an intermediate temperature sufficiently high that atomic mobility and diffusion will permit precipitation in what might be called colloidally fine dispersion in the aluminum matrix.

The origin and reason for the terms "age-hardening," "dispersion-hardening," and "precipitation-hardening" are

now clear and it will be equally evident why alloy hardening of this type is sometimes more broadly called "suppressed-transformation" hardening. Comparison of this type of hardening with that of steel will reveal interesting similarities as well as differences. Precipitation-hardening appears much simpler in phase or structural mechanism than the quench-hardening of steel, but it does require more steps in its practical execution. Both are of the suppressed-transformation category.

AGE-HARDENING ART HAS SPREAD RAPIDLY.

The prescription for precipitation-hardening aluminum was soon demonstrated to be applicable to other metals and alloys—as indeed must evidently be true. Most metals have the power of absorbing other metals and elements into solid solution and the solubility of these addition elements usually increases with temperature. By proper "addition-alloying" practically all metals, and many alloys as well, can be transformed into potentially age-hardenable ones, which then require only the standard "solution treatment" and quenching, followed by aging, to develop enhanced hardness and strength.

During the last two decades, both the science and the art of hardening alloys have enjoyed rapid development. A compilation, probably not complete, made about ten years ago revealed the disclosure in patent and technical literature of some fifty age-hardening alloy systems based upon pure metals alone. This list has certainly grown still further in the last decade and must be augmented also by the many age-hardening systems now known, based upon alloys such as brass, copper-nickel, alloyed gold, etc. Many of these age-hardening alloy systems have come into industrial use and today several important metals and many alloys are available industrially in age-hardenable alloyed modifications; witness beryllium-bronze, "Tempalloy," calcium-lead, "Z" nickel, "K-Monel," the hardenable dental gold alloys, etc.

The degree of enhancement of hardness and strength possible through age-hardening varies of course, but at its best is quite considerable. Many alloys in use, or disclosed in the literature, exhibit enhancement of both hardness and strength of as much as 100 per cent. and even more.

Thus pure copper with a Brinell hardness of 35 and a tensile strength (annealed condition) of about 35,000 psi is alloyed with 2.5 per cent. beryllium to yield a "beryllium-bronze" which may be heat-treated to a hardness of 400 and a tensile strength of well over 150,000 psi. Age-hardenable alloys with a gold, silver, copper, and platinum base are produced today which upon heat-treatment will develop tensile strengths of 175,000–200,000 psi, which are impressive in comparison with the strength of the base metals which in no case exceeds about 35,000 psi.

PRECIPITATION-HARDENING ART AIDS IN "BUILDING" ALLOYS.

In addition to the service which many of the individual modern hardenable alloys are rendering to industry, the now pretty well understood science of precipitation-hardening makes a contribution to what in default of a better term may be called the art of building and designing alloys.

Alloys are useful only by reason of their physical, chemical, and other properties and these alloy properties are required today, for engineering design and industrial manufacture, in sets or groups of the most diversified character. One alloy material must be corrosion-resistant, abrasion-resistant, strong and readily fabricable by forging and machining. Another must have high electrical conductivity but yet be strong and fabricable by rolling and drawing into cable and wire.

Unfortunately many industrially useful alloy properties appear to be inherent only in the elemental atoms themselves and are not producible at will. When we want electrical conductivity, for example, we must use copper or silver; when we want chemical passivity we look to chromium. Our choice of metals for meeting certain property specifications is limited and our possibilities for alloy design in these directions, therefore restricted.

But in the property of hardness and its associated property of strength, we now have, through the art of precipitation-hardening, one set of important properties which more or less at will, we may enhance in any base alloy chosen for other considerations. We are in position to do this fairly well for the simple reason that we can generally find a suitable age-hardening addition element for any base alloy which will

confer age-hardening properties even when added in modest percentage, insufficient to modify unduly the other properties of the base alloy.

Thus, lead for cable sheathing may be converted into a substantially age-hardenable modification by the addition of as little as 0.1 per cent. of calcium. The steel alloy, invar, useful because of its low thermal expansion is a comparatively soft material. By adding amounts of aluminum or titanium, less than 3 per cent. in total, together with suitable changes in the base composition of the invar, a hardenable invar may be produced which has not suffered unduly in respect of thermal expansion. The copper-nickel alloy, Monel Metal, used because of its corrosion-resistance, may be transformed by additions of less than 4 per cent. of aluminum into K-Monel Metal which retains the corrosion-resistance of Monel Metal but acquires through suitable aging heat-treatment tensile strength values of 160,000 psi and higher, associated with substantial ductility and machinability.

Thus the art of flexibly building desired properties into industrial alloys, surely a major goal of alloy metallurgy today, has been carried an important step forward through recognition of the possibilities and methods of precipitation-hardening.

AGE-HARDENING FACES IMPORTANT PROBLEMS.

What has been said so far has manifestly been over-simplified in statement, and if it has too casually left the impression that all is "beer and skittles" in this new field of alloy metallurgy, I hasten to correct such an impression.

For the beneficial practical values of the practice of age-hardening have not been secured without encountering off-setting disadvantages with which there must be constant struggle. I note the irritating disposition of age-hardening alloys to continue to age at temperatures within their age-hardening range and therefore to alter in properties (although some are notably resistant to the change); their tendency to become embrittled under certain conditions; the difficulties usual in thermally hardenable alloys, of welding and making castings; the failure of certain important mechanical properties, notably fatigue strength, to respond fully to age-

hardening treatment. I note finally that we are now compelled to recognize age-hardening as an almost too universal and frequent phenomenon, since we often find alloys undergoing aging changes of an undesirable character, alloys not even designed to be subject to age-hardening but which turn out to be so because of the presence of minute quantities of impurity elements. Thus the well-known blue brittleness of steel is now known to be due to a type of age-hardening and the degradation in drawing quality of certain steels with time is a related phenomenon.

Nor even has the simple theory of the mechanism of age-hardening gone unchallenged, but on the contrary it has provoked counter-theories and has raised a number of important and interesting physical questions about which controversy rages most hotly and, unnecessary to add, most interestingly. A major phase of the current controversy over the physical theory of precipitation-hardening is, to put it rather simply, whether the age-hardening agent is composed of discrete particles of a crystalline precipitate in the usual sense, or whether the hardening is accomplished by a host of embryo precipitate particles in some sort of pre-precipitation stage somewhere intermediate between the condition of a tiny but complete crystal and that of atomic dispersion. As usual in such controversies there is evidence in support of both the older, simpler view and of the later ones. I do not propose to air the controversy further here.

I do wish, however, in conclusion to note that these difficulties and these controversies are but standard features of all new developments, and that as in other similar situations metallurgical science is not only struggling with them with reasonable success but is even deriving additional benefits and values of a by-product nature from them; in the improvements in fabricating and other metallurgical arts which attend the overcoming of some of these practical difficulties and in the new insight and understanding which discussions and their underlying investigations of the nature of age-hardening throw on the nature generally of atomic and group changes in solid metallic crystals and lattices—and on the fundamental nature of the formation of one crystal lattice from and within another.

Finally this prospect cannot escape our attention. By

combined accident and anguish, metallurgical science has established the existence of hitherto unsuspected, but certainly most useful, properties in a certain state of metallic matter which may be termed that of partially arrested and incompleted lattice or crystal transformation. Such matter is of course in a state of more or less controllable instability, and the successive stages or steps through which matter may pass in controlled transition through its complete transformation must be many, indeed infinite. It seems not improbable that as we experiment, observe, and understand further this aging method of conducting transformations in metals we shall find additional useful intermediate states which, although unstable, may be held in suspense at suitably low temperatures and which may exhibit other striking physical properties not now known. Indeed in the quite unsuspected field of magnetic materials suppressed transformation technique has already yielded some useful prizes. And so, as always, new developments in the alloy or any other field often serve as the starting points of other and even more useful ones.

I. EVALUATION OF THE PEANUT AS A CASH CROP.

II. IMPORTANCE OF THE PEANUT FROM A BIO-CHEMICAL STANDPOINT, ESPECIALLY FROM THAT OF NUTRITION.

BY

SAMUEL L. JODIDI, Ph.D.

I. EVALUATION OF THE PEANUT AS A CASH CROP.

In a former publication (5) attention was called to the inadequacy of our knowledge regarding the growth of the peanut plant, its adaptability to certain soil and climatic conditions, and its dependence on physical and chemical factors, all of which is naturally bound to influence the development of the plant, the pods and the seeds. For instance, while the Virginia type of peanut is well adapted to but a restricted area in southeastern Virginia and northeastern North Carolina, the Spanish type of peanut appears to do well in the whole of the southeastern part of the United States. While lime in the soil generally benefits peanut plants, fresh manure when applied to the soil particularly at planting time seems to produce a large percentage of poorly filled pods. Again, it was stated or implied that whereas some types of peanut are known ordinarily not to form "pops," other types frequently do so; that is, they develop poorly filled pods.

To what extent those phenomena are related to or caused by variations in temperature, light, soil texture, cultivation, and other environmental conditions is not known. The chemical analyses of the kernels and pods as to their content of ash, fat, nitrogen, protein, reducing and total sugars, etc. were made to ascertain whether there was a relationship between the chemical components on the one hand and the development of the plants and the yield of their fruits on the other.

The object of this paper is to point out the value of the

peanut as a cash crop and to emphasize the possibility of increased peanut consumption and expansion of production.

Peanuts, almost all of which are grown in the Southern States, are the basis of a considerable industry. This is

TABLE I.

Peanuts: Acreage, Yield, Production, Price per Pound Received by Farmers, Value, United States, 1916–1940.[1]

Year.	Acreage Grown Alone for all Purposes.	Acreage Picked and Threshed.	Yield per Acre.	Production.	Price per Pound in the Shell.	Farm Value.
	1,000 Acres.	1,000 Acres.	Pounds.	1,000 Pounds.	Cents.	1,000 Dollars.
1916		923[2]	801.6	739,915	4.65	34,407
1917		1,559[2]	726.1	1,131,934	7.12	80,585
1918		1,545[2]	648.9	1,002,561	6.45	64,708
1919		957	719.2	688,270	9.40	64,686
1920		995	699.3	695,842	4.82	33,573
1921		980	692.0	678,200	3.86	26,183
1922		821	637.4	523,345	5.37	28,094
1923		797	712.9	568,150	6.48	36,839
1924	1,394	1,084	657.6	712,815	5.81	41,400
1925	1,279	996	724.6	721,660	4.50	32,446
1926	1,154	860	770.0	662,190	4.83	31,970
1927	1,489	1,086	777.4	844,220	5.12	43,243
1928	1,636	1,213	695.4	843,505	4.96	41,799
1929	1,627	1,262	711.7	898,197	3.75	33,704
1930	1,433	1,073	649.9	697,350	3.58	24,997
1931	1,773	1,440	733.2	1,055,815	2.02	21,359
1932	2,042	1,501	627.0	941,195	1.54	14,512
1933	1,717	1,217	673.5	819,620	2.84	23,292
1934	2,015	1,488	678.7	1,009,950	3.32	33,480
1935	1,959	1,473	778.8	1,147,225	3.14	36,069
1936	2,067	1,606	780.3	1,253,090	3.74	46,878
1937	1,932	1,500	816.1	1,224,190	3.31	40,471
1938	2,160	1,708	764.5	1,305,800	3.28	42,861
1939	2,410	1,859	634.5	1,179,505	3.42	40,294
1940	2,390	1,907	845.1	1,611,635		

[1] The figures given in Table I for 1916–1939 were taken from U. S. Department of Agriculture Agricultural Statistics 1940, while those for the year 1940 were obtained from U. S. Department of Agriculture Crop Reporting Board for December, 1940.

[2] The years 1916 to 1918 inclusive, harvested for nut, are not comparable with the years 1919–1940.

plainly evident from Table I in which acreage yield, production, and price per pound of peanuts are given. While the number of acres planted to peanuts fluctuated from year to year, the tendency toward an increase of the acreage is un-

mistakable. Thus, from 1,394,000 acres devoted to peanut culture in 1924, the figure for 1940 rose to 2,390,000, representing an increase of one million acres. Taking the average

TABLE 2.

Peanuts Imported into and Exported from the United States, 1916–1940.

Year Ended December 31.	Imported into the United States.				Exported from the United States.	
	Peanuts, Shelled.		Peanuts, Unshelled.			
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	1,000 Pounds.	1,000 Dollars.	1,000 Pounds.	1,000 Dollars.	1,000 Pounds.	1,000 Dollars.
1916	17,179	663	8,482	327	18,375	929
1917	42,578	2,012	7,689	326	12,891	1,093
1918	67,747	4,276	1,971	129	12,319	1,603
1919	24,180	1,934	5,667	394	19,778	2,123
1920	110,810	10,571	8,703	772	9,366	1,115
1921	35,640	1,522	4,524	203	14,493	954
1922	8,051	384	3,115	137	12,621	835
1923	48,364	2,294	3,938	174	4,806	459
1924	55,976	2,468	4,952	206	3,127	321
1925	73,134	3,692	10,457	507	3,489	319
1926	42,590	1,984	3,990	190	4,232	347
1927	38,805	1,651	4,490	179	4,827	393
1928	55,862	3,065	13,739	591	5,419	523
1929	26,631	1,272	4,609	194	4,880	408
1930	5,123	216	3,218	107	2,960	246
1931	6,229	191	4,277	115	1,842	139
1932	59	2	473	10	7,107	202
1933	115	2	180	4	1,426	66
1934	260	14	352	7	616	44
1935	33	4	233	7	226	27
1936	80	5	312	11	256	25
1937	1,263	80	796	34	407	44
1938	6,192	250	443	15	619	62
1939	6,862	345	332	10	750	73
1940 Preliminary	4,739	264	145	6	703	78

Office of Foreign Agricultural Relations.

Compiled from Foreign Commerce and Navigation of the United States and Official records of the Bureau of Foreign and Domestic Commerce.

annual production as around 900,000,000 pounds at the conservative price of three cents a pound, the value of the peanuts raised per annum for the period 1916 to 1940 amounted to about $27,000,000. In recent years, the annual value has

been above $40,000,000. Among industries based on peanuts may be enumerated here the peanut candy in the form of peanut bars, peanut brittle, sugar-coated and chocolate-

TABLE 3.

Peanut Oil Imported into and Exported from the United States, 1916–1940.

Year Ended December 31.	Imported into the United States.		Exported from the United States.[1]	
	Quantity.	Value.	Quantity.	Value.
	1,000 Pounds.	1,000 Dollars.	1,000 Pounds.	1,000 Dollars.
1916	15,674	1,174	—	—
1917	27,405	2,673	—	—
1918	68,466	8,531	—	—
1919	154,052	22,010	4,342[2]	1,043[2]
1920	95,124	16,990	1,425	291
1921	3,021	314	1,708	183
1922	2,470	281	963	101
1923	8,009	760	203	19
1924	15,395	1,326	39	4
1925	3,027	387	—	—
1926	8,281	866	—	—
1927	2,847	340	—	—
1928	4,749	520	—	—
1929	3,231	333	—	—
1930	15,565	949	—	—
1931	14,886	645	—	—
1932	1,489	90	—	—
1933	1,318	81	—	—
1934	2,722	136	—	—
1935	80,723	3,367	—	—
1936	49,006	2,642	—	—
1937	57,999	3,601	—	—
1938	15,553	611	—	—
1939	3,779	175	325	33
1940 Preliminary	3,119	195	2,853	273

Office of Foreign Agricultural Relations.

Compiled from Foreign Commerce and Navigation of the United States and official records, Bureau of Foreign and Domestic Commerce.

[1] Not separated prior to July 1, 1919, and 1925–1938; if any included in "Other expressed vegetable oils."

[2] July 1–December 31.

coated peanuts (19); peanut butter (prepared by grinding roasted and blanched peanuts to which about two per cent. of salt is added); peanut oil (prepared by pressing the nuts);

peanut cake and peanut meal (1, pp. 292–298). Mention should also be made here of the peanut hay of which one to one and one-half tons per acre is obtained (1, p. 290), and which represents a valuable forage for horses, cattle, and sheep. Due to the frequent changes in the yield and the price of peanuts the interlocking farm values show corresponding fluctuations, as would be expected.

The Peanuts Imported into the United States.

Due to the great nutritive value of peanuts and to the circumstance that they are in great popular favor, the United States imported considerable quantities of peanuts prior to 1930. Since 1930, the increased production in the United States has almost supplied the demand so that imports have been dropped to a relatively small quantity.

Peanut Oil Imported into the United States.

Peanut oil has been imported in considerable quantities in certain years as is evident from Table 3. The figures show plainly that whereas the quantities of peanut oil imported in any one year, for the period 1916–1940, were quite considerable and varied widely from year to year, the amounts of peanut oil exported were generally rather insignificant as compared with imports in the corresponding years. Furthermore, from 1916 to 1918 and from 1925 to 1938 peanut oil exports were too small to justify reporting separate from other vegetable oils. On deducting the quantities of peanut oil exported, the net annual quantity of peanut oil imported for the entire period under consideration was, on an average, almost 26,000,000 pounds. From 1931 to 1940, inclusive, peanut oil imports averaged about 23,000,000 pounds per year, with an annual value of over $1,000,000.

Peanut Oil as Substitute for Olive Oil.

Olives are known to have been cultivated for centuries in the Mediterranean countries, particularly in Italy, France, Greece, and Spain. Olives of good quality are grown also in the United States, especially in California and Arizona. However, the demand for olives as such, particularly for pickled green olives, is very brisk throughout the country. For this reason it is not surprising that producers of olives

prefer to pickle and sell them in this form rather than to crush them for making oil. The result is that olive oil is imported from foreign countries in large quantities as is manifest from Table 4. The figures show that for the period 1916–1940 the

TABLE 4.

Imports of Olive Oil into the United States, 1916–1940.

Year Ended December 31.	Quantity.		Value.	
	Edible.	Inedible.	Edible.	Inedible.
	1,000 Pounds.	1,000 Pounds.	1,000 Dollars.	1,000 Dollars.
1916	55,435	6,334	10,416	681
1917	51,055	4,476	9,441	570
1918	1,284	3	451	[1]
1919	67,681	2,118	18,014	435
1920	30,591	496	12,169	132
1921	49,711	4,171	11,151	436
1922	61,187	27,788	11,811	1,964
1923	77,190	40,605	12,218	3,394
1924	76,186	31,918	12,585	2,960
1925	90,426	51,707	15,656	4,467
1926	78,506	50,225	13,901	4,609
1927	75,025	49,126	17,577	4,809
1928	82,944	48,271	14,951	4,071
1929	96,798	56,206	16,408	4,467
1930	92,964	69,896	11,221	4,061
1931	70,385	48,969	8,253	2,655
1932	74,274	57,668	6,975	2,341
1933	71,963	53,373	6,649	2,400
1934	56,008	45,836	6,989	2,842
1935	70,789	53,540	8,758	3,730
1936	60,972	29,446	7,437	2,319
1937	48,343	26,980	8,988	2,725
1938	71,086	27,800	9,786	1,805
1939	62,866	39,484	8,077	2,520
1940 Preliminary	50,080	29,616	6,781	1,915

Office of Foreign Agricultural Relations.

Compiled from Foreign Commerce and Navigation of the United States, and official records of the Bureau of Foreign and Domestic Commerce.

[1] Less than 500.

annual import of edible oil amounted to 64,950,000 pounds worth $10,667,000, as well as 34,242,000 pounds of inedible oil worth $2,492,000. Since no olive oil was exported in any one year, the figures just given mean that, in round numbers,

the annual quantity of edible and inedible olive oil imported into the United States amounted to 99,000,000 pounds, worth $13,000,000.

The question naturally arises: Can peanut oil be employed to replace olive oil? In this connection it is well to keep in mind that the peanut oil has been found in quality to be equal to olive oil and can therefore be applied to all purposes for which olive oil is used. Indeed, great quantities of peanut oil were at one time used, unknown to the consumer, in place of olive oil (4, p. 18; 1, p. 298). As in the case of olive oil, the highest quality of peanut oil is prepared by pressing sound nuts at ordinary temperature and at relatively low pressure, which gives a small yield of oil but of a quality satisfactory for table use. On the other hand, when nuts are preliminarily cooked to start the oil and then subjected to high pressure, a much larger yield of crude peanut oil is obtained which can be used for mechanical purposes. It should be mentioned that if desired the crude peanut oil prepared by the hot process can be refined and deodorized to render it usable for the table (1, p. 298).

Another question that suggests itself is this: Would it be feasible to grow the additional quantity of peanuts sufficient not only to meet the domestic demands for peanuts but also for the production of peanut oil and as substitute for olive oil? During the past 10 years imports of olive oil have averaged slightly over 100,000,000 pounds annually. As the peanut oil is practically in all its qualities, including the specific gravity, equal to olive oil, the 100,000,000 lbs. of olive oil, or the equal quantity of peanut oil, would require 400,000,000 lbs. of peanuts in the shell, for which 533,000 acres for growing peanuts would be needed. Altogether it might be necessary to devote to peanut cultivation additional 680,000 acres in order to fully cover the demands of the home market for peanuts, peanut oil, and olive oil.

As compared with the peanut acreage of 1940, the figures just computed would mean a stepping up of 23 per cent. of the acreage for peanut raising. The additional acreage for peanut cultivation could be taken at the expense of other crops of the South, for instance, cotton of which a large surplus is on hand. The additional acreage of 23 per cent., if desired,

could be diminished by increasing the yield of peanuts per acre through the employment of advanced scientific methods, such as the application of proper fertilizers in proper stages of the crop, or of improved intensive methods of cultivation, or of higher-yielding peanut varieties, or by a combination of all these factors. The possibilities of increasing the yield per acre are rather striking when it is recalled that, whereas the average yield is about 36 bushels, or 800 to 1,100 lbs. per acre, many cases have been recorded where a yield of 1,800 to 2,000 lbs. per acre has been harvested (2; 2a, p. 32).

(To be continued in September issue.)

NOTES FROM THE NATIONAL BUREAU OF STANDARDS.*

CONSTANT OF GRAVITATION.

A new determination of the Newtonian constant of gravitation is reported in a paper (RP1480) by Paul R. Heyl, which will be published in the July number of the Journal of Research. The apparatus used was the torsion balance, and the general plan of the work was the same as that published in *BS J. Research*, **5**, 1243 (December, 1930); RP256. The method makes use of the change in the time of swing of a torsion pendulum resulting from the presence or absence of large attracting masses in its immediate neighborhood.

A number of improvements in the apparatus were suggested, some of which were tried, and two of which were adopted. The unsuccessful trials are discussed in detail for the benefit of future workers. The two changes adopted were the use of photographic recording of the time of swing in place of visual observations, and a change in the position of the large attracting masses which greatly simplified the length measurements. Two different tungsten filaments were used as a suspension for the pendulum, one hard drawn and one specially annealed and kept straight during the drawing and subsequent handling. Contrary to expectations, it was found that the results with the hard drawn filament were the more precise. The only advantage of the annealed filament was that it did not require as much time for aging after installation, which, of course, is a factor of importance where time is an object, as in geophysical prospecting for oil.

The final result obtained was:

$$G = 6.673 \pm 0.003 \times 10^{-8} \text{ cm.}^3 \text{ g.}^{-1} \text{ sec.}^{-2}$$

As compared with the 1930 result of $6.670 \pm 0.005 \times 10^{-8}$, it will be seen that the increase in precision is hardly ap-

* Communicated by the Director.

preciable. It may therefore be concluded that the limiting point of diminishing returns has been reached with this form of apparatus.

FLOW OF WATER IN OPEN CHANNELS.

In problems involving the computation of the flow of water in open channels, the fact that the velocity is not the same at all points of any lateral cross-section of the stream leads to the introduction of a "velocity-distribution coefficient" in the flow equation. Two different methods of computing this coefficient have been given in the past, leading to slightly different forms of the equation. One of these methods was developed by Coriolis and involved averaging the cubes of the local velocities. The second method of computing the velocity-distribution coefficient was due to Boussinesq and involved averaging the squares of the local velocities. A controversy has existed over this discrepancy in the flow equations for more than half a century without any satisfactory explanation of the difficulty. Coriolis' point of view has generally prevailed, however.

In the July *Journal of Research* (RP1488), G. H. Keulegan shows that there are two methods of deriving the equation for turbulent flow in open channels. Both are based on the fundamental equations of hydrodynamics, but the methods of derivation proceed by somewhat different paths, although having the same starting point. In one of the methods the terms in the equation that is integrated have the dimension of rate of change of energy. This will be called the "energy method." In the other method, the terms have the dimension of rate-of-change of momentum. This will be called the "momentum method."

In the final flow equations derived by each of these two methods, certain terms occur which can be combined to form a single term containing a so-called friction coefficient. It is found that in the equation derived by the energy method, this "friction coefficient" is actually related to the rate of energy dissipation in the water and that the velocity-distribution coefficient has the form of the Coriolis coefficient. On the other hand, in the equation derived by the momentum

method, the friction coefficient is directly related to the wall friction, and the velocity-distribution coefficient has the form of the Boussinesq coefficient.

Thus it appears that it is correct to use either the Coriolis or the Boussinesq coefficient, providing the proper interpretation is placed on the friction coefficient in the equation. Practically, however, it is preferable to use the equation derived by the momentum method.

PROTECTION OF RADIUM DURING AIR RAIDS.

Since the involvement of this country in the present war, numerous requests have been received for information on the safe storage of radium during air raids. The Bureau has standardized nearly all the radium sold in this country during the past 30 years, so it is natural that users of this material should turn to it for adequate information on the protection of individuals from the effects of dispersal of radium by bomb explosions.

As a result of these requests, the following committee was appointed to draft recommendations: L. F. Curtiss, National Bureau of Standards, chairman; Dr. G. Failla, Memorial Hospital, New York, N. Y.; Dr. John E. Rose, Tumor Clinic, U. S. Marine Hospital, Baltimore, Md.; Dr. Curtis F. Burnam, 1418 Eutaw Place, Baltimore, Md.; Dr. Harrison S. Martland, Newark City Hospital, Newark, N. J.; Prof. George B. Pegram, Columbia University, New York, N. Y.; and Sherwood Smith, War Department, Washington, D. C.

This committee has prepared Handbook H38, giving suggestions for storage of the various types of preparations in common use. The suggested procedures aim at a reasonable degree of protection with a minimum interference with the use of the radium. The availability of materials and their cost were also given full consideration in the selection of methods.

If these recommendations are followed, the committee believes there will be little chance of injury to individuals from radium scattered as the result of bomb explosions, even in the rare case of a direct hit on the storage chamber. Since the

probability of air raids is greatest near the coast, the Committee advises all users of radium within 500 miles of any coast line to give special consideration to the problem.

Although protection for the more common types of preparations is discussed in the Handbook, the Committee realizes that exceptional situations may exist, and offers to give consideration to these cases on request. Correspondence should be addressed to the Radioactivity Section, National Bureau of Standards.

Copies of H38 are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents each.

AUSTENITIC GRAIN SIZE IN STEELS.

Steel may be hardened or softened by heating to certain high temperatures and then cooling either rapidly or slowly. The grain size established in the steel at these high temperatures (the austenitic grain size) often has a decided effect upon certain properties of the steel. It is important, therefore, to know the effect of different variables upon the grain size at heat-treating temperatures.

Thomas G. Digges and Samuel J. Rosenberg of the Bureau's Metallurgy Division recently completed a study of the influence of different initial structures and of different rates of heating upon the austenitic grain size at 1475° and 1600° F. of an iron-carbon alloy and two commercial steels containing 0.5 per cent. of carbon. As reported in the July *Journal of Research* (RP1481), they found that the initial structure had but a minor influence upon the grain size of either the iron-carbon alloy or the steels. The rate of heating had a very pronounced effect upon the grain size of the iron-carbon alloy, rapid rates causing the formation of rather small grains, whereas slow rates resulted in the formation of extremely coarse grains. The rate of heating had but a slight effect upon the grain size of the steels, but when such an effect did exist it was opposite to that found in the iron-carbon alloy in that the finest grains were produced with slow rates of heating.

HARDNESS OF STEEL PLATES.

It is generally agreed that moderate cold-rolling of steel causes increases in its indentation hardness. This conclusion is based on results of indentation hardness tests which take into account the over-all effect of cold working of the metal. However, during moderate cold-rolling, the behavior of the metal at and near the surface (commonly designated surface layer) may differ from that of the metal more remote from the surface. Since the structure of the surface layer has been shown to be affected to different degrees by different mechanical surfacing treatments, it appears that the manner of surface finishing a metal prior to rolling may influence the behavior of the surface layer during light cold-rolling.

In coöperation with the Bureau of Engraving and Printing, Harry K. Herschman is studying the influence of surface finishes on the response of 0.34 per cent. carbon steel plates to incising processes common to the engraving art. The hardness of the plates at and near the surface is one of factors believed to have an important bearing on the response of the steel to these incising operations. Exploratory indentation hardness tests made on a plate which had been burnished by light cold-rolling indicated a "softening" of the metal immediately adjacent to the surface. This prompted a more systematic investigation of the indentation hardness of the surface layer after different degrees of cold-rolling. The steel prior to rolling was finished by three different methods, grinding, buffing, and polishing. Indentation hardness tests were made with an elongated pyramidal diamond (Knoop) indenter and with the Rockwell superficial hardness machine.

As set forth in RP1484 in the *Journal of Research* for July, the results of tests with the Knoop indenter, using light loads (50 to 200 grams) on the indenter, showed that the hardness of the metal in the immediate vicinity of the surface, as distinguished from the underlying metal, was lower after cold-rolling reductions of 1 and 2 per cent. than it was prior to rolling. These results suggest that the most significant decreases in hardness occurred in a surface layer less than 0.0003 inch thick. Indentations made with the Knoop indenter under relatively heavy loads (1,000 and 2,000 grams)

and with the Rockwell superficial machine were too deep to detect hardness changes in the superficial layer. The test data suggest that the magnitude of the indentation hardness changes in the surface layer of the steel in the pre-rolled and rolled conditions was influenced by the nature of the initial surface finishing treatment.

SPECIFIC HEAT OF THE SYNTHETIC RUBBER, HYCAR O.R.

Knowledge of the basic thermodynamic constants of two substances permits a calculation of the equilibrium constant in chemical reactions involving the formation of one from the other. Previous work of this sort has been carried out at the Bureau to obtain information about the polymerization reaction of isoprene to form rubber, and its reverse, the decomposition of rubber to give isoprene.

Similar data concerning synthetic rubber have recently become of increased importance. Research Paper RP 1487 by Norman Bekkedahl and Russell B. Scott in the July issue of the *Journal of Research* reports the first measurements necessary for evaluating the thermodynamic constants of the synthetic rubber, Hycar O.R. The specific heat of this material has been measured or evaluated from the absolute zero of temperature to about 70° C. The specific heat at 25° C. was found to be 1.971 international joules/degree gram. It was not found possible to crystallize or melt the material, but a second-order transition, one which involves no appreciable absorption or evolution of heat, was found at about −23° C. A similar transition in natural rubber occurs at about −70°. It would appear that below the temperature of its second-order transition a material is brittle and relatively inextensible.

The increase in entropy resulting from heating from the absolute zero of temperature to 25° C. was calculated from the specific heat data to be 1.743 international joules/degree gram.

MICROSCOPIC STRUCTURE OF FLAX.

With the loss of European sources of supply of flax fiber, a renewed interest in all aspects of the flax problem has

been manifested, and accordingly, an investigation of the microscopic structures of flax and related bast fibers was undertaken as a research project of the Textile Foundation at the Bureau. A report on this work by Charles W. Hook will be published as RP1482 in the July *Journal of Research*.

The stem of the flax plant consists of two main parts, a central woody core, and a surrounding cortex which contains the bast fibers. The cambium layer lies between these regions. Retting, which is one of the procedures carried out during the freeing of the fibers from the stem, involves essentially a softening of the tissues, usually by bacterial action, to permit separation of the fibers from the other parts of the stem. The cambium layer is attacked first during this treatment, followed later by attack on other thin-walled cells in the cortex.

Flax fibers are obtained from the stem in the form of long filaments which vary in length from several inches to more than a yard. Each fiber is made up of cells, which are usually about one inch long and one one-thousanth of an inch in diameter. Other bast fibers such as hemp, jute, and ramie have a similar origin and structure. Although the bast fibers have many structural details like those in cotton, they differ from it in one important respect. Whereas a cotton fiber is a single plant cell, a bast fiber is made up of a group of cells.

A flax cell has a primary and a secondary wall. The former constitutes the surface of each cell and consists largely of wax and other material, much of which has generally been assumed to be of a pectic nature. The secondary wall, which comprises the bulk of the fiber, is made up of innumerable cellulose fibrils, the outermost layer of which winds in one direction, whereas the majority of the fibrils beneath this layer wind in the opposite direction. These fibrils, which are similar to those found in many other plant cell walls, are grouped so as to give the wall a layered pattern. There is a greater number of these layers in the walls of the flax cells at the base of the stem than in the cells from the growing tip. A corresponding increase in thickness of the wall, from the tip of the stem where the cells originate to the base where they mature, also prevails. All the bast fibers have essentially

similar structures. Flax and ramie, however, differ from hemp and jute in the directions of fibrillar orientation, and this accounts for some of the differences in the physical properties of the two groups.

ELASTICITY OF WOOL.

Wool is of particular value in those branches of the textile industry that manufacture apparel, fabrics, blankets, carpets, and felts—commodities which are important because of their warmth or their elasticity; that is, their ability to regain their original lengths or shapes after they have been distorted. Actually, this elasticity is primarily responsible for the warmth of wool, in that it allows the fabric to maintain a porous structure. The small air spaces in such a structure impart to the fabric its insulating properties. Thus, a cotton blanket would be as warm as wool if, instead of matting together in use, it would maintain a porous structure as does a woolen blanket.

The basis of the elasticity of wool has been extensively investigated by Research Associates of the Textile Foundation stationed at the Bureau. In the July *Journal of Research* (RP1486), Milton Harris, Louis R. Mizell, and Lyman Fourt, state that wool apparently owes its elasticity to a rubberlike molecular structure, the molecules being distinguished by their freedom to assume various shapes. This is in contrast to most of the other common fibers, which resemble bundles of closely packed extended strings, each string representing a long molecular chain.

When these string-like fibers are distorted very much, the long chains move into new positions with respect to each other. Since, in a fiber such as cotton, the new positions are similar to the old, the fiber does not return to its original shape. The ease with which this can occur is one of the principal reasons why cotton and similar materials crease so readily. The molecules of wool fibers would also slide past one another and permanent distortion would be produced if they were not connected at intervals by short cross chains which produce a three-dimensional or network structure. Thus, when wool is stretched or folded, the chains

do not slide permanently out of position; rather, tensions are set up which cause the fiber to return to its original shape after the removal of the external force.

It is of interest to note that the function of the cross-chains in wool is very similar to that of the cross-chains which are presumably formed during the vulcanization of rubber. Indeed, the similarities between these materials are so striking that wool may in a sense be considered to be a vulcanized fiber, in which respect it differs from all other textile fibers.

WATER PERMEABILITY OF WALLS BUILT OF MASONRY UNITS.

Masonry walls usually perform well the functions for which they were built, including protection from the weather. However, they may be penetrated by wind-driven rain with possible damage to the interior, and the resistance to rain penetration of walls built of masonry units is therefore of importance to the home owner and the builder.

The water permeability of different kinds of small experimental walls built of masonry units has been determined by testing specimens under conditions which produced the effects of a wind-driven rain. The most important factors affecting permeability were the extent to which the interior vertical joints were filled with mortar, the brick-suction or tendency of the bricks to absorb water when laid, and the water-retentivity of the mortar.

The least permeable brick walls were built by filling the vertical joints with mortar or with grout, and by wetting medium- to high-absorptive bricks before placing them in the faces of the walls. Cement-lime mortars of high water-retentivity contained limes of high plasticity, and such mortars were used in building the least permeable walls. The mason also experienced less trouble when laying bricks with such mortars than was found for mortars of a relatively low water-retentivity.

The complete account of this work has been published as Building Materials and Structures Report BMS82, copies of which are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C. The price is 20 cents.

LEAD-BASE SOLDERED JOINTS IN COPPER TUBING.

The use of copper pipe for domestic plumbing lines and certain other purposes was greatly retarded until the development of a satisfactory soldered joint made thin-walled hard-drawn copper tubing practicable for such service. Recently, as part of a general program sponsored by the Copper and Brass Research Association, the merits of tin-base soft solder for these joints were studied and a favorable report was issued (BMS-58). However, it was found necessary to recommend that the use of the soldered joints be limited to service in which the prevailing temperatures did not exceed 250° F. Supplementing this early work, a study has just been completed on similar joints made by the use of lead-base solders. An important aim in this work, which is described in detail in Building Materials and Structures Report BMS83, was to find a solder that could be recommended for use at temperatures higher than 250° F. The desire to replace tin by a metal more easily obtained also was a vital consideration.

Joints made with lead-base solders of the following types were tested: lead-silver, lead-cadmium, lead-tin-antimony, high lead-low tin, and high-purity lead. Specimens made by joining two short pieces of copper tubing by a soldered sleeve coupling were tested at temperatures ranging from room temperature to 325° F., the joint being maintained under tensile loading for very long periods. The information obtained from a simple short-time laboratory test at room temperature is not adequate to permit a proper evaluation of the durability of a joint, hence the need for a "long-time" test carried out at the temperature expected in service.

A joint in copper made with tin alloy soft solders and maintained at an elevated temperature for a very long time may suffer deterioration of the bond between the copper and solder film. Alloying by diffusion between the tin of the solder and the copper base accounts for this deleterious change. As a result, the solder film in the joint loses ductility and the strength of the assembled joint is lowered. It was largely for this reason that it was considered necessary for joints made with tin-base solder to set a temperature which must not be exceeded in service. At temperatures below 250° F., the adverse change in the joint is so slight as to be negligible.

Joints made with the lead-base solders listed were found to have strengths considerably higher at 250° F. and slightly higher at 325° F. than did joints made with (50–50) tin-lead solder. Deterioration of the bond was not observed in lead-base solders free from tin. Of the different lead-base solders used, lead-silver is most practicable from most standpoints. A solder containing lead and silver in the ratio 96 : 4 is probably the best "all round" soft solder of this class. The technique of its application, however, is not nearly so simple and easy as is the application of common (50–50) tin-lead solder.

Copies of BMS83 are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C. The price is 10 cents.

Reduction of Metallic Ores by Natural Gas.—FRANK H. DOTTERWEICH. (*Refiner and Natural Gasoline Manufacturer*, Vol. 21, No. 5.) Reduction of metallic ores, especially iron ore, is being accomplished in localities favored by desirable proximity to the required raw materials such as coking coal, limestone, ores and favorable location relative to transportation. The Pacific Coast states have high-grade iron ores, but in the absence of coal of coking quality this operation has not become practical. Announcement of the Clarkiron Process, developed by Walter Gordon Clark of Los Angeles, comes at a time in which the expansion and separation of the metallurgical industry is highly desirable. The process consists of the reduction of metallic ores in relatively finely divided form, by natural gas. This process has successfully passed the pilot plant stage and is available to reduce iron, chrome, nickel, vanadium and titanium on a commerical basis. The ore is crushed so that it passes a ½ inch mesh. It is then transferred to a roaster heated by natural gas in addition to hot gases from the reducing apparatus. After the temperature of the ore reaches 1500° F. it is delivered to the top of a 115-foot reduction stack provided with blast furnace traps and means for controlling the ore's movement through the stack. As the ore passes down through the stack it meets with the upward moving gases, hydrogen, methane, and water vapor. There are three movable induction coils along the stack, each coil raising the temperature of the ore 100° F. The action of the induction coils is entirely magnetic. Reduction starts in the field of the first coil. The hydrogen from the natural gas, being cracked at the base of the reduction stack, reduces the downward moving ore. The gas, as it comes into contact with freshly reduced hot ore, is cracked into hydrogen and carbon so completely that only ½ per cent. or less of methane is left as a residue. From estimates to date this process may operate on an investment per ton of output, substantially less than that required per ton of pig iron.

R. H. O.

THE FRANKLIN INSTITUTE.

MEDAL DAY MEETING.

The Franklin Institute again gathered together at its annual Medal Day, this year held the third Wednesday in April, scientists from all over the country in order to pay honor to them for their many contributions to society.

As soon as the procession entered the Hall, Mr. Marriner, Associate Director in charge of music on the staff of The Franklin Institute, played the Star Spangled Banner, which was sung by the audience.

At three-thirty the meeting was called to order by the president, Mr. Charles S. Redding. The president stated that inasmuch as this was the regular monthly meeting he would call upon the secretary for his report.

It was noted that the minutes of the meeting of the previous month had been printed in full in the April JOURNAL. The members were called upon to register any objection. As there was none, the minutes were declared approved as printed.

The secretary, Doctor Henry Butler Allen, requested that all routine business be dispensed with in order that the award of Medals might proceed.

Before the awards were made, the chairman spoke as follows:

"Through many years it has been the pleasure and the privilege of The Franklin Institute to honor workers in the vast field of science. Many have been pioneers, beginning their explorations, others have been chosen for a life-time of work; in some cases the awards have been to men of outstanding distinction in the field of applied science; in others they have gone to workers in the laboratories, the men who lay the groundwork and who often go unsung! Recognition by The Franklin Institute frequently constitutes the first step to later fame.

"You may be interested to know how the awards are made. One of the first acts of the Board of Managers of the infant Franklin Institute, founded in 1824, was to appoint a Board of Examiners, whose duty it was to examine and make reports upon all new and useful machines, inventions and discoveries submitted to it. That Board has been in constant existence ever since. In 1834 its name was changed to "The Committee on Science and the Arts." Today it continues as a self-perpetuating, hard-working group of approximately sixty members. This number is broken up into small sub-committees, each appointed to consider a particular case. It is necessary for the reports of these sub-committees to be read at two separate meetings of the full committee before final adoption of their reports. The findings of the Committee, together with the recommendations for the awards, are then passed upon by the Board of Managers and become final.

"The awards to be made today represent the work of this Committee for the past year. As you will see, they have been especially discerning."

PRESENTATION OF CERTIFICATES OF MERIT.

To the Goodyear Tire and Rubber Company of Akron, Ohio. Received by Mr. Paul W. Litchfield, Chairman of the Board.

Mr. Redding recognized Doctor Julian W. Hill, sponsor.

Doctor Hill: "Mr. President, the Board of Managers of The Franklin Institute, upon recommendation of its Committee on Science and the Arts, has awarded a Certificate of Merit to The Goodyear Tire and Rubber Company of Akron, Ohio, 'in consideration of the development and successful manufacture of a safety tire which lessens the risk of damage to life and property caused by tire blowouts.' The Company has delegated the Chairman of its Board, Mr. Paul W. Litchfield, to receive the Certificate in its behalf. I present Mr. Litchfield."

Mr. Redding: "We are delighted to present this Certificate to you on behalf of your Company and appreciate your kindness in coming to receive it."

To John J. Grebe, D.Sc., Director, Physical Research Laboratory, Dow Chemical Company of Midland, Michigan.

Mr. Redding called the next sponsor, Mr. E. L. Forstall.

Mr. Forstall: "The Committee on Science and the Arts voted the award of a Certificate of Merit to Dr. John J. Grebe, Director, Physical Research Laboratory, Dow Chemical Company of Midland, Michigan, 'in consideration of his invention of a metal screen which effectively reduces solar radiation entering through windows.' Dr. Grebe."

Mr. Redding: "You have added to the comfort of us all, so with this Certificate I extend to you our gratitude for your invention."

To Walter Larkin, Fidelity Machine Company of Philadelphia, Pennsylvania.

Mr. Redding called upon the sponsor, Mr. J. S. Rogers.

Mr. Rogers: "The Board of Managers has sanctioned the award of a Certificate of Merit to Mr. Walter Larkin, Fidelity Machine Company, Philadelphia, Pa., 'in consideration of his admirable machine designing involving the ingenious application of known mechanical movements to the invention of circular knitting machines of special types.' It is my privilege to present Mr. Larkin."

Mr. Redding: "It is always an especial pleasure to have a fellow-citizen among our medalists. We are proud of you as the representative of our Philadelphia scientists today."

PRESENTATION OF LONGSTRETH MEDALS

Jointly to Ralph E. Flanders, D.Sc., D.Eng., President, and Ernest V. Flanders, Manager, Thread Grinder Division, Jones and Lamson Machine Company, Springfield, Vermont.

Mr. Redding called upon Mr. F. G. Tatnall, sponsor.

Mr. Tatnall: "Mr. President, the award I sponsor represents a repetition of history. In 1921 the President of the Jones and Lamson Machine Company of Springfield, Vermont, was awarded a Longstreth Medal for his invention of the Screw Thread Comparator. At the time the award was being considered, Mr. James Hartness was President of the Company. At the time the award was made he was Governor of the State of Vermont.

"Today I have the honor to present to you another President of the Jones and Lamson Machine Company, and his brother who cooperates in keeping the wheels of industry turning in the plant at Springfield, as Manager of the Thread Grinder Division.

"Time does not permit me to give you in detail the interesting story of how these gentlemen turned the period of depression to one of accounting by their invention, but the whole story is written up in the May 1941 *Fortune* Magazine. It makes interesting reading.

"A Longstreth Medal has been voted jointly to these two gentlemen 'in consideration of the development of a thread grinding machine, including a method for truing the grinding-wheel, its mounting and control, insuring accuracy and variability of the resulting screw threads.'

". . . Dr. Ralph E. Flanders, President, and Mr. Ernest V. Flanders, Manager, Thread Grinder Division, Jones and Lamson Machine Company."

Mr. Redding: "Gentlemen, by power vested in me as President of The Franklin Institute, I present to you the Longstreth Medal . . . and as a fellow toolmaker offer you my hearty congratulations!"

To Charles Maxwell Kearns, Project Engineer, Hamilton Standard Propeller Company of East Hartford, Connecticut.

Mr. Redding called upon Dr. R. Eksergian, sponsor.

Dr. Eksergian: "Mr. Chairman, I present, for the award of a Longstreth Medal, Charles Maxwell Kearns, Project Engineer, Hamilton Standard Propeller Company, East Hartford, Connecticut, 'in consideration of the successful application of methods for the measurement of strains in aircraft propellers under flight conditions.'"

Mr. Redding: "Mr. Kearns, I present you with this Longstreth Medal, with much pride in the work you aircraft men are doing."

PRESENTATION OF BROWN MEDAL.

To Duff Andrew Abrams, Consulting Engineer, New York City.

Mr. Redding called upon Professor C. M. Gay, sponsor.

Professor Gay: "Mr. President, the Brown Medal is to be awarded today for the second time. It was founded in 1938 and is bestowed 'for invention and discovery in the building and allied industries.' The gentleman to receive it is well known in engineering circles and is honored today 'in recognition of his discovery of the fundamental bases of design for concrete and reinforced concrete mixtures.' I present Mr. Duff Andrew Abrams, Consulting Engineer of New York City.

Mr. Redding: "Mr. Abrams, by virtue of my authority as President I have much pleasure in making this presentation to you, Sir."

PRESENTATION OF LEVY MEDAL.

To John Donovan Strong, Ph.D., Assistant Professor of Physics in Astrophysics, California Institute of Technology, Pasadena, California.

Mr. Redding called upon Mr. J. Winlock, sponsor.

Mr. Winlock: "The award of the Levy Medal each year brings to the fore another long-time and important activity of The Franklin Institute, for it is given to the author of a paper of especial merit, published in the JOURNAL of The Franklin Institute. The JOURNAL is a technical publication, highly regarded in its field. Those whose papers are published in the JOURNAL await eagerly the pronouncements of the Board of Managers.

"This year the Medal is bestowed upon Dr. John Donovan Strong, Assistant Professor of Physics in Astrophysics, California Institute of Technology, Pasadena, California, 'for his paper entitled "On a New Method of Measuring the Mean Height of the Ozone in the Atmosphere" which appeared in the February issue of the JOURNAL of The Franklin Institute for 1941.'

"I regret to have to report that Dr. Strong, who was with us three years ago when he received a Longstreth Medal, was unable to make the trip this year. I, therefore, Mr. President, present him to you, *in absentia*, and request that the Medal be given to the Secretary of the Institute, for transmission to Dr. Strong."

Mr. Redding: "Mr. Secretary, this Medal now becomes your responsibility."

PRESENTATION OF POTTS MEDALS.

To Jesse Wakefield Beams, Ph.D., Professor of Physics, University of Virginia, Charlottesville, Virginia.

Mr. Redding called upon Dr. W. R. Wright, sponsor.

Dr. Wright: "It is my privilege to sponsor the award of the Howard N. Potts Gold Medal, given for 'distinguished work in science or the arts; for important development of previous basic discoveries; for inventions or products of superior excellence or utilizing important principles.'

"The Committee on Science and the Arts has recommended for this award, Dr. Jesse Wakefield Beams, Professor of Physics, University of Virginia, 'in recognition of his contributions to the problem of high speed rotation and of his successful development of a wide variety of ultracentrifuges.'

"I present Dr. Beams."

Mr. Redding: "By power vested in me as President of The Franklin Institute I hand you this Medal and the Certificate accompanying it and offer my congratulations upon the award.

To Harcourt Colborne Drake, Director of Research, Sperry Products, Inc., Hoboken, New Jersey.

Mr. Redding called upon Dr. W. S. Pardoe, sponsor.

Dr. Pardoe: "The Board of Managers has sanctioned the award of a Potts Medal also to Harcourt Colborne Drake, Director of Research, Sperry Products, Inc., 'in consideration of inventions and important work in the development of the rail fissure detector car, affording valuable results in the saving of life and property.' . . . . Mr. Drake."

Mr. Redding: "Mr. Drake, your presence here pleasantly reminds us that representatives of your Company in other years have earned our awards. We hope we may have occasion to welcome you back for ever increasing honors!"

To Bernard Lyot, D.Sc., Meudon Observatory, Paris, France. Received by M. Patrick Coppinger, Consul for France.

Mr. Redding called upon Mr. W. H. Fulweiler, sponsor.

Mr. Fulweiler: "Mr. Chairman, a Potts Medal has also been awarded to Dr. Bernard Lyot of the Meudon Observatory, Paris, France, 'in consideration of the first successful

observations of the solar corona in the absence of a total eclipse.'

"In happier times perhaps Dr. Lyot would have been with us to receive his Medal in person. Unfortunately the condition of world affairs is such that we have not been able to hear from Dr. Lyot.

"But Monsieur Patrick Coppinger, Philadelphia Consul for France, has kindly consented to act on behalf of his countryman and will receive the award for transmission to Dr. Lyot.

"I present Monsieur Coppinger."

Mr. Redding: "Science knows no country. Its universal character brings us together whatever turmoil may prevail. We are grateful to you for coming here today to aid us in its name! I present to you this Medal and Certificate for transmission to Dr. Lyot.

M. Coppinger: "It will be a comfort for Doctor Lyot to have this award, for it will show that the American scientists and the French scientists can get together in the common cause of science."

PRESENTATION OF CRESSON MEDALS.

To Claude Silbert Hudson, Ph.D., Professor of Chemistry, National Institute of Health, U. S. Public Health Service, Bethesda, Maryland.

Mr. Redding called upon Dr. J. W. Hill, sponsor.

Dr. Hill: "Mr. President, our Cresson Medal will soon be celebrating its hundredth anniversary. It was founded in 1848 and is given for discovery or original research, and invention, and through the years has gathered to itself a distinguished group of scientists. We are proud today to add to that list the name of Dr. Claude Silbert Hudson, Professor of Chemistry, National Institute of Health, who has been voted a Cresson Medal 'in consideration of his distinguished investigations in carbohydrate chemistry, which have greatly enriched our knowledge of this field and stimulated the work of other investigators through the formulation of general principles and the development of new and improved experimental procedures.'"

Mr. Redding: "By virtue of my office I have much pleasure in presenting to you the Elliott Cresson Gold Medal and Certificate which accompanies it. We are delighted to add your name to our honor roll."

To Isidor Isaac Rabi, Ph.D., Professor of Physics, Columbia University, New York City.

Mr. Redding called upon Dr. C. B. Bazzoni, sponsor.

Dr. Bazzoni: "Mr. President, the Cresson Medal claims another outstanding scientist! I have the honor to present to you, Sir, Dr. Isidor Isaac Rabi, Professor of Physics, Columbia University, to whom the Board of Managers has voted the award of a Cresson Medal, 'in recognition of the basic importance of the Rabi magnetic resonance method for investigating the properties of atomic nuclei—an importance already demonstrated by a variety of achievements.'

"Dr. Rabi."

Mr. Redding: "Dr. Rabi, by power vested in me as President of the Institute I present to you this Cresson Medal, together with the Certificate which accompanies it. We consider you a great addition to our honor list."

PRESENTATION OF THE FRANKLIN MEDAL AND CERTIFICATE OF HONORARY MEMBERSHIP.

To Jerome Clarke Hunsaker, D.Sc., Professor in Charge, Daniel Guggenheim Aeronautical Laboratory, Massachusetts Institute of Technology; Chairman, National Advisory Committee for Aeronautics.

Mr. Redding called upon Dr. Frederic Palmer, Jr., sponsor.

Dr. Palmer: "Dr. Hunsaker's early study of the dynamical stability of airplanes, carried out both in this country and abroad, led to his construction, at Massachusetts Institute of Technology, of a wind tunnel for testing airplanes and also to the establishment of the first course in the United States in the field of aerodynamics and airplane design. During the first World War the Navy Department made him responsible for the design, construction, and procurement of naval aircraft, an assignment which he carried through with such success that for it he received the Navy Cross.

"His contributions to aeronautical science include the design of the NC type of flying boat, one of which made the

first trans-Atlantic flight in 1919; the design of the first large airship built in the United States (the Shenandoah); the design of the first anti-submarine patrol airships; the design of light planes for use on an aircraft carrier together with launching catapults and arresting gear for deck landings; the design of an air-cooled radial airplane engine; the use of tank testing for boats and tunnel testing for planes; and the development of a gas-tight airship fabric. These accomplishments in the field of aeronautics have brought to him wide recognition as well as the responsibilities of the many offices to which he has been appointed or elected.

"Hence, 'in recognition of his pioneer work in education in the field of aeronautical science, and of his many valuable contributions to that science,' I take pleasure in presenting, as a candidate for the Franklin Medal, Jerome Clarke Hunsaker, Aeronautical Engineer, Head of the Department of Mechanical Engineering, at Massachusetts Institute of Technology, Chairman of the National Advisory Committee for Aeronautics."

Mr. Redding: "Dr. Hunsaker, by power vested in me as President of The Franklin Institute, I have the honor and the pleasure of presenting to you the Franklin Medal and Certificate, together with a Certificate of Honorary Membership in The Franklin Institute. We are greatly honored by your presence here today. Dr. Hunsaker will now tell us somewhat of his own researches in aeronautics." (Dr. Hunsaker's paper, "Research in Aeronautics," appears on page 133 of this issue.)

PRESENTATION OF THE FRANKLIN MEDAL AND CERTIFICATE OF HONORARY MEMBERSHIP.

To Paul Dyer Merica, Ph.D., Sc.D., Vice-President and Director, International Nickel Company of Canada.

Mr. Redding called upon Dr. Frederic Palmer, Jr., sponsor.

Dr. Palmer: "Shortly before the first World War there was developed in Germany an alloy of copper and aluminum which we now call 'duralumin.' When this alloy is heated to 500° C. and then quenched its hardness is only moderate; but after aging for a few days its hardness, strength, and ductility all are found to increase very greatly. Twenty-five years

ago Dr. Merica made a study of this peculiar property of duralumin as a result of which he proposed a new theory to account for its behavior, namely, that at the higher temperature copper is readily soluble in solid aluminum, but this solubility diminishes rapidly as the temperature falls, resulting in a solution of copper in aluminum which is supersaturated at room temperature; hence copper is precipitated throughout the aluminum with a consequent increase in hardness and strength of the alloy. This process of heat treatment is now known as 'precipitation hardening,' and it is applicable to many other alloys beside duralumin.

"Dr. Merica has been notably successful in improving the properties of many alloys and adapting them to new commercial uses. For instance, the hardness and strength of duralumin combined with its lightness have made it an invaluable material in the field of airplane construction.

"Hence, 'in recognition of his theoretical work on the precipitation hardening of alloys, and of his practical work in the development of the art of heat treatment of alloys to the end that they acquire properties which make them commercially of greater usefulness,' I present to you, Sir, as a candidate for the Franklin Medal, Paul Dyer Merica, Metallurgist, Vice-President of the International Nickel Company."

Mr. Redding: "Dr. Merica, by power vested in me as President of The Franklin Institute, I have the honor to present to you the Franklin Medal and Certificate and the Certificate of Honorary Membership which enrolls you in the Institute. It is a pleasure to have you here today.

"Dr. Merica has prepared a very interesting paper on 'The Precipitation-Hardening of Metals' . . . Dr. Merica." (Dr. Merica's paper, "The Precipitation-Hardening of Metals," appears on page 137 of this issue.)

Mr. Redding: "Before adjourning the meeting I would like to express our deep appreciation to our Medalists for their coöperation in being with us today. We all realize that in these busy times it takes effort and ingenuity to be in all the places we are supposed to be at a given time. And I want to say a word of welcome to medalists of other years who have come back to us this afternoon. Year after year we hope to see the number increase. We feel that science is the

bond which brings us together, and the Institute is the home of science, so come often, but especially on Medal Day.

"The museum of the Institute will be open this afternoon until six o'clock. If any of our guests would like to wander around you will be quite welcome to do so.

"The meeting stands adjourned."

MEDAL DAY DINNER.

Reception to President and Mrs. Redding.

At a quarter past seven o'clock, over three hundred guests assembled at a reception given by the Hostess Committee to meet Mr. Charles S. Redding, who had been elected President of The Franklin Institute in January of this year, and his wife.

The reception was immediately followed by dinner at eight o'clock in Franklin Hall.

Introduction of Guests of Honor.

At nine-fifteen the program was begun by the playing of The Star Spangled Banner by Mr. Marriner, after which a toast (in water) was drunk to Benjamin Franklin.

The presiding officer, Mr. Redding, President of The Franklin Institute, spoke as follows:

"Medal Day is the high point in The Franklin Institute year. In the afternoon we honor those who have distinguished themselves in Science and the Arts. In the evening we do them further honor and at the same time have several hours of delightful association.

"This is the first time it has been my privilege to preside at the Medal Day functions and I do so tonight with some trepidation in the presence of two distinguished predecessors. Those predecessors successively guided the affairs of the Institute for the past thirteen years and I am going to ask them to rise for a moment and to receive your applause in appreciation of the fine work which they did. First, Mr. Nathan Hayward, who was President from January 1929 to January 1937, and Mr. Philip C. Staples, who was President from January 1937 to December 1941 inclusive.

"I am very happy to state that these two gentlemen re-

main on our Board of Managers and that we still retain their active interest and support. We lean upon them very heavily.

"We have many distinguished guests with us this evening. Here at the head table are seated the gentlemen whom we were proud to honor this afternoon. Some have come long distances to be with us; all have taken the time from very busy lives. We wish to express our appreciation to them and to the others here tonight who, by their presence, have declared their interest in science and the things science stands for.

"Before I introduce these gentlemen I would like to say a word about Medal Day. From its very inception The Franklin Institute chose the award of medals as its mode of giving encouragement to young scientists and of honoring men who had devoted long years of labor to scientific research. Through the years these awards of The Franklin Institute have acquired a justly deserved, worldwide reputation which, when Medal Day is announced, brings together such a gathering as this.

"It is not by accident that this has happened. The recommendations to the Board of Managers of The Franklin Institute for the award of Certificates and Medals is in the hands of a group of approximately sixty men, known as 'The Committee on Science and the Arts.' Just recently one of our members has established a Certificate, named for George A. Hoadley, for many years Secretary of the Committee. This award goes to members of the Committee who have served for twenty-five years or more. In the first group to receive the Certificate, the aggregate number of years of service of eleven men totaled three hundred and ninety-nine years!

"To date twenty such Certificates have been awarded. It is a gracious gesture and emphasizes the fact that mature judgment is utilized in considering the awards. I want to point out, however, that the Committee is self-perpetuating, and that young blood is constantly being added. You must remember that these men, all members of The Franklin Institute, serve with no thought of remuneration, attend meetings ten months in the year when the general Committee meets, in addition to countless sub-committee meetings which are called to consider individual cases. When a case comes

before the Committee, a sub-committee of four or five men, whose own work makes them familiar with the subject to be acted upon, is appointed. To that little group is allotted the task of searching records, conducting correspondence, examining models, and handling endless details in order that, when the award is made, the recipient may receive it with full confidence that the Committee feels it is richly deserved.

"This year the Board of Managers feels that the Committee has been most discerning. Your programmes will tell you the reasons for the awards. As I call the names I am going to ask the gentlemen at the head table to stand and remain standing until I finish. May I ask you to restrain your applause until the end?

"Our Franklin Medalist: Dr. Jerome Clarke Hunsaker of the Massachusetts Institute of Technology, who has been called by our Government to be Chairman of the National Advisory Committee for Aeronautics—honored for his noted work in aeronautics.

"Another Franklin Medalist: Dr. Paul Dyer Merica, Vice-President and Director of the International Nickel Company of Canada—a distinguished metallurgist.

"The Cresson Medalists: Dr. I. I. Rabi, Columbia University, outstanding research man in the field of physics;

"Dr. Claude S. Hudson, sugar chemist of renown; and an important member of the staff of the National Institute of Health of the United States Public Health Service.

"The Potts Medalists: Mr. Harcourt C. Drake, Director of Research, Sperry Products, Inc., developer of the rail fissure detector, which has resulted in the saving of life;

"Dr. Jesse Wakefield Beams, Professor of Physics, University of Virginia, who has made highly important contributions to the development of ultracentrifuges.

"Our Brown Medalist: Mr. Duff Andrew Abrams, consulting engineer of New York City, who put the preparation of concrete on a thoroughly scientific basis.

"The Longstreth Medalists: Mr. Charles Maxwell Kearns, Project Engineer of the Hamilton Standard Propeller Company, who has applied methods for measuring strains in aircraft propellers under flight conditions which have brought about interesting results:

"Dr. Ralph E. Flanders and Mr. Ernest V. Flanders, of the Jones and Lamson Machine Company, who have turned out machines which are the marvel of modern science and which are so desperately needed today.

"And our Certificates of Merit winners: Mr. Walter Larkin of the Fidelity Machine Company in Philadelphia, developer of remarkable machines in the knitting industry;

"Dr. John J. Grebe, Director of the Physical Research Laboratory of the Dow Chemical Company, responsible for a type of screen which keeps us cool in summer and warm in winter.

"And lastly, to the Goodyear Tire and Rubber Company of Akron, Ohio, for the successful manufacture of a safety tire which lessens the risk of damage to life and property.

"This Certificate was received this afternoon by the Chairman of the Board of that Company, Mr. Paul W. Litchfield, who was delegated by his Company to represent it here today.

Presentation of Speaker.

"I am afraid that, if I had not explained to you how tried and true our men are who recommend the awards, you might by now be suspecting us of intrigue in making the award to the Goodyear Company. The tire situation is pretty bad! I can assure you, however, that the case was duly considered and the Certificate voted strictly on its merits. However, we have asked Mr. Litchfield what can be done about it, whether we might hope for a suitable substitute, and he has consented to tell us what he can. How about the tire situation, Mr. Litchfield?" MR. LITCHFIELD responded:

THE TIRE AND RUBBER SITUATION.

The question is of great current interest and, although you are riding in automobiles *today*, most of you are wondering how long you are going to have tires to keep your cars in operation. I will try to give you a little outline which may supply the answer to some of the questions now in your mind.

Malaya and the Dutch East Indies have been the source of practically all of our rubber. The supply in those areas

was so great that we have been confronted with large surpluses for many years—so much so that a Cartel of British and Dutch was found necessary to limit production and to maintain an orderly market with fair prices.

One result of this Cartel was that it had restricted production to the point that when war broke out United States had the smallest supply of rubber on hand in many years. I believe we had manufactured about 760,000 tons during the last year but had reduced our inventory by another 70,000 tons to make a total national consumption of 830,000 tons in 1941.

We realized that we might face the same situation we did in the last war—a shortage of shipping. National planning was directed toward this danger and little thought was given to other possibilities. So the first job we had to do was to get rubber into America and begin building up the stock pile as best we could. Meanwhile there was the problem of stabilizing prices and this problem was uppermost in the minds of the British and Dutch growers. A huge stock pile in our hands could easily constitute a surplus which would throw the market out of balance for many months and seriously disrupt the economy of the rubber growing areas.

The war risk was so great, however, that the decision was made to have our government take over the whole matter, working with the Dutch and British to bring in rubber as fast as possible. Ultimately we piled up 650,000 tons in this country—the largest inventory in all times. But at the same time, our government began its program of rationing and the public was confused by the apparent contradiction of a huge stock pile and a tire shortage.

Then the matter of synthetic production came up. The only thing we can substitute for rubber with any degree of economy at all is synthetic. Germany was far ahead of us in this field. They had developed synthetic rubber during the last war and had carried on a consistent program of plant expansion through subsidies. Even though they had ample supplies, the Reich took drastic steps to conserve rubber the minute war was declared.

Until Pearl Harbor we were not seriously concerned with the synthetic situation because we figured that by June, 1942,

we would accumulate as big a stock pile of crude as we could possibly need. Nobody foresaw, except possibly the Japanese, what was going to happen in January of this year. The invasions of Malaya and Dutch East Indies presented an abrupt reason for revising all of our planning.

The question then came up, what to do? An inventory was taken as to just where we stood. In the face of a consumption in ordinary times, as in, say, 1941 and other years, it was estimated that it would take some 800,000 tons—and we had a stock pile of 650,000 tons, and very little more coming in. In fact, if we get 150,000 tons in 1943 and 150,000 tons in 1944, it is about all we can expect. You talk of the rubber in Brazil and Africa and how we used to get it from there, but you must remember when you were getting most of the rubber from Africa the consumption was not as great. Even the amount of rubber we might be able to get out of Brazil would not give us more than about 46,000 tons. It is only by the greatest difficulty and the expenditure of an enormous amount of money that you can appreciably increase the Brazilian supply in the next two years.

We have our stock pile and we can reclaim old rubber at the rate of about 350,000 tons a year. Our other big reserve is the rubber now on the automobiles in private hands—we estimate this amount at about one million tons. This must be rigidly conserved.

At the same time, the government is embarking upon a program of synthetic plant construction which will provide an annual capacity of 750,000 tons. You may ask why this was not undertaken at a much earlier date, and the answer is that, in the light of events, it should have been. However, let's not forget that prior to Pearl Harbor we dealt with one set of facts, and after Pearl Harbor there was a drastically new base for such decisions.

It will cost between five and six hundred million dollars for the plants required by the 750,000 ton synthetic program and it will take at least two and one-half years to get going on that.

Obviously we must conserve every possible ounce of the supplies we now have on hand. We must save enough out of our crude stock pile to mix with the synthetic we will be

producing, and we must take care of our military needs as well as the servicing of cars for necessary defense work and essential civilian use. The manufacture of all passenger car tires has been stopped since the 17th of December.

I don't think we realize what the situation is—it is going to be two or two and a half years until you will have any for civilian use. There will probably be enough to take care of all the military needs of the country and by compounding down in the new specifications coming through, we can probably take care of the essential needs of the war time economy and enough to take the defense workers to the plant, which is one of the uses to which a good portion is put at the present time.

The government is tightening up the restrictions more than ever—more and more all the time—and I think it is only a question of time until we will have to go further on gas rationing, if for no other reason than to save the tires not being used for war purposes. Rubber is the first war casualty and over night the Japanese took over the rubber plantations that were producing from 90 to 94 per cent. of the rubber in the world and producing it at less than half the cost of producing synthetics. If we had had sufficient aircraft alone, the Japanese would never have captured those plantations. To recapture them we not only must have dominant air power, but land and sea power as well. So the situation facing us is that with a national consumption in the neighborhood of 800,000 tons a year with less than 100,000 tons coming in, we must conserve all the rubber we can, until the synthetic plants are in operation, and then we will go back to the production of tires—although they will be more expensive because of the increased cost of synthetic rubber.

After an expression of thanks to Mr. Litchfield for his highly informative paper, Mr. Redding continued the meeting as follows:

Introduction of Former Medalists.

"We have been delighted this year to welcome back many Medalists of former years. I wonder if they will stand and take a bow as I call the names, and please remain standing.

"Dr. L. H. Adams, Washington, D. C., Longstreth, 1921.

"Dr. Newcomb K. Chaney, United Gas Improvement Company, Philadelphia, Pa., Potts, 1939.

"Mr. Philip T. Dashiell, United Gas Improvement Company, Philadelphia, Pa., Clark, 1932.

"Mr. Alfred V. DeForest, Magnaflux Corporation, New York City, N. Y., Longstreth, 1936.

"Mr. John V. N. Dorr, New York, N. Y., Scott, 1916.

"Dr. Rupen Eksergian, E. G. Budd Mfg. Company, Philadelphia, Pa., Henderson, 1937.

"Mr. Peter P. G. Hall, The Hall Planetary Company, Philadelphia, Pa., Longstreth, 1936.

"Mr. Thomas R. Harrison, Certificate of Merit, 1932.

"Mr. Mayo D. Hersey, Morgan Construction Company, Worcester, Mass., Levy, 1936.

"Mr. Hiram H. Hirsch, Philadelphia, Pa., Longstreth, 1914.

"Mr. Stewart S. Kurtz, Jr., Sun Oil Company, Marcus Hook, Pa., Levy, 1938.

"Mr. Morris E. Leeds, Leeds and Northrup, Philadelphia, Pa., Longstreth, 1920.

"Dr. Francis F. Lucas, Bell Telephone Laboratories, Wetherill, 1935.

"Dr. G. H. Meeker, Philadelphia, Pa., Longstreth, 1906.

"Mr. Irving E. Moultrop, Belmont, Mass., Cresson, 1930.

"Mr. Harry S. Parks, Pottstown, Pa., Longstreth, 1923.

"Dr. Charles Rosenblum, Princeton University, Princeton, New Jersey, Levy, 1940.

"Mr. Milton R. Sheen, Philadelphia, Pa., Longstreth, 1924.

"Dr. James E. Shrader, Philadelphia, Pa., Wetherill, 1935.

"Mr. Elmer A. Sperry, Jr., Sperry Products, Inc., Brooklyn, N. Y., Longstreth, 1936.

"Mr. Warren P. Valentine, Philadelphia, Pa., Longstreth, 1928.

"Mr. E. Burke Wilford, Pennsylvania Aircraft Syndicate, Philadelphia, Pa., Certificate of Merit, 1939.

"Mr. Benjamin J. Wilson, Oreland, Pa., Longstreth, 1941.

"Are there any former Medalists whose names I have not called?

"I hope you will all come back each year. We shall be glad to see you whenever you can get here.

Presentation of Secretary and Director.

"In every organization there is one person who holds the reins, who smooths out the difficulties, who guides everyone in the way they should go! Here at The Franklin Institute it is our genial Secretary and Director, Dr. Henry Butler Allen. Tonight he has a very special duty to perform, which gives us all much gratification . . . but I will let him tell you about it. . . . Dr. Allen."

Honorary Membership for Senator Pepper.

"Dr. Allen: Mr. President, Medalists, Members and Friends:

"Two years ago, on this occasion, I recalled the prostitution of science by the aggressor nations for the fiendish war which they had started, and called attention to *our* field of usefulness through promoting true science and Benjamin Franklin's homely wisdom.

"At our last year's Medal Day Dinner I touched upon The Franklin Institute streamlining its activities for the *coming* defense of *our* homes and traditions.

"*Tonight* I can report to you that the Institute is taking its rightful place in winning this desperate war—the fifth in its history.

"How *fortunate* the Institute is that it can turn its normal activities so *directly* to our country's service. Our technical library—our museum and its technical staff—our research laboratories, our Science and Arts Committee are all needed and doing their part. For *this* war does *not* permit 'business as usual.' It goes *beyond* being a '*war to preserve democracy.*' *It is a war to save civilization.*

"But the Institute thinks it can help *even beyond* the fields of *science.* In *dedicating* this Franklin Memorial, Senator George Wharton Pepper said '. . . we mean to keep Franklin *among us* as a *living being* so that we may get to know him well. If we do *this* he will influence our *lives* and help us become better citizens.'

"Our management has felt that the assumption of *this*

responsibility is *another* way in which we can serve our country.

"So we have organized, through the help of our friend, Mr. William Vermilye, the National Franklin Committee, of which he has accepted chairmanship. This group has *already* started to awaken our countrymen to the farsighted wisdom of Franklin as a *good counsellor and guide* in these 'days which try men's souls.'

"Mr. President, the Institute showed *good judgment* last month. It elected to pay tribute to a great humanitarian—one who has been *our* wise counsellor in our effort to reincarnate the homely virtues of Franklin—one who, four years ago, in unveiling this great statue, welcomed the world to Franklin's 'New Home.'

"Honorary membership is one of the highest honors the Institute can bestow. By curious coincidence *this particular membership* certificate bears the date of its recipient's 75th birthday—see how fitting that this is so.

"Let's look back and see what happened to Dr. Franklin in *his* 75th year. He was elected an honorary member of the Academy of Sciences, Letters, and Arts at Padua, a Fellow of the American Academy of Arts and Sciences at Boston, appointed a Commissioner by Congress to negotiate peace with Great Britain. In that year he tried to resign as Minister to France but Congress wouldn't let him, whereupon he proceeded to get *further* loans of six million livres from Holland and France for *his United States*.

"Mr. President, I have the honor to present to you for the award of honorary membership in The Franklin Institute one who holds the respect and love of all—'In consideration of his inspiring leadership in the movement to reincarnate in *our* times the homely virtues of our patron, Benjamin Franklin, thereby increasing human understanding and kindling anew *courage*, *loyalty* and *patriotism*,' the Honorable George Wharton Pepper."

Mr. Redding: Mr. Pepper, this represents but one more bond to draw you closer in an association which already has placed us all overwhelmingly in your debt. This Certificate is given in gratitude and affectionate regard.

Mr. Pepper graciously acknowledged the honorary award of a Certificate of Life Membership in the Institute, and as a speaker of the evening delivered the following paper:

BENJAMIN FRANKLIN, THE APOSTLE OF UNITY.

In giving me this certificate the Institute has taken a much greater risk than in awarding medals to those who have severally received them. The certificate is a guaranty of what I am: the medal is merely recognition of the recipient's specific accomplishment. However a medalist may cut up in the future, the Institute can shrug its shoulders and say "We merely honored his past: we didn't guarantee his future." But if I get gay in my old age and forsake the straight and narrow path of scientific solemnity, the stars in the Planetarium will hide their faces and the mechanical man on the ground floor will shed real tears.

I have to admit that in popular estimation a medal has always outranked a certificate. But all of us certificate-holders can console ourselves with the reflection that gold is at a discount and is good only to be buried—whereas paper is at a premium and a paper certificate is something to write home about.

There is one aspect of this matter that will keep my head from swelling and that is the fact that the medal boys and the recipients of other certificates are being decorated for merits of their own—whereas I am certified merely because I have recognized and proclaimed the merits of Dr. Franklin. This is really an easy road to distinction: one need not subject himself to the annoyances of virtue: all he need do is to proclaim the virtues of the other fellow. In the case of Dr. Franklin this is easy to do because his merits were many and they were of the sort of which today we stand in desperate need. When in the presence of foreign peril he is said to have observed "We must all hang together—or we'll hang separately" he said a mouthful. Whether he really said it or not makes little difference—for his whole course of conduct was in accord with that warning. He was in fact the Apostle of Unity. It you doubt it, read his address on "Plain Truth" with which he roused the people of Pennsylvania to a realization of their peril.

It wouldn't be a bad slogan for Americans of today. At the moment we seem to be going our several ways in calm assurance that Victory will in due time perch upon our banner. We need a reminder from Dr. Franklin that Victory in this kind of a war is not to be attained except by a long pull, a strong pull and a pull all together. I know a lot of people who claim that they understand this situation and that they are all set to win the war—but only in their own way. Even among men in the armed forces there are jealousies and mutual distrust: Army men and Navy men talking and acting as if this was a football game between West Point and Annapolis. In the interest of unity, I am glad to note that the President is assuring our friends from South America that they will have a share in making the ultimate peace. Of course this assurance must presuppose that they are first going to share in winning the war.

If Dr. Franklin were here to speak his mind he would have nothing but praise for those who in every line of activity are striving for maximum production; but he would in his own effective way remind us that uncoördinated efforts are quite as futile as inertia. The production of goods for shipment must be accompanied by the production of ships; and in the building of ships there must be concerted activity between the builders of the hull and the constructors of the machinery—and so on and so on. While he would not hesitate to utter such plain truths as these he would never do it in anger or for the purpose of fixing blame. He would keep on proclaiming the facts until those responsible were forced to take effective action. His criticisms would always be made with Victory in view—not defeat.

Nor would he be discouraged by the course of events which fill some people with gloom. Even when the world was certain that our Revolution had ended in disaster he went about his work with a smile and always emphasized the factors favorable to victory. He would remind us that there is nothing surprising in the number of obstacles in the path of preparedness. "Do you expect" he would ask "that people who yesterday could not agree on the best make of automobile or the most satisfying cigarette or the most edifying church or the most effective political party could over-night

develop unanimity on war and how it should be conducted?" On the other hand, while undiscouraged, he would keep on proclaiming that unity is the price of Victory and that if a man wants to force the enemy to surrender he must begin by himself surrendering some of his pet ideas.

While diversity in details is always wholesome and while in peace-time there is legitimate room for diversity in many great matters, in war-time the area of permissible diversity grows smaller and smaller. One-ness wins a war: lack of it spells inevitable defeat. It has always seemed to me that the only thing that can give coherence and continuity to life—either in war-time or in peace—is the willingness of everybody to address himself with conviction to "OUR FATHER WHO ART IN HEAVEN." I am not thinking merely in terms of prayer but in terms of unification of thought. Unless people are bound together by recognition of a common Fatherhood no other tie can exist except something transitory and inadequate—such as the blind following of an individual whose sudden collapse leaves one with no place to go. The conception of Universal Fatherhood excludes the tribal god and provides a universal standard of conduct. When a nation or group of nations sets up a formula of brutal selfishness and undertakes to force its acceptance on the rest of mankind we can brand this as a defiance of a universal standard—the standard to which we conform when we address ourselves to the Father of All and ask that His Name be hallowed and His Will done. Instantly patriotism takes on a noble meaning and the fight, instead of international strife, becomes a fight to vindicate eternal principles.

All this Franklin understood—not as a man who had adopted the convictions of others as his own—but as one who had lived for a time on lower levels and had come to his philosophy of life through bitter experience. The prayer with which he concluded his pamphlet on "Plain Truth" is a recognition of the unifying effect of the conception of Universal Fatherhood. The statement that he made in the Constitutional Convention was of the same sort. He had come to the fixed belief that except the Lord build the house their labor is but lost who build it and that except the Lord keep the city the watchman waketh but in vain.

This is the simple and soul-satisfying philosophy which he is commending to each of us today. If we accept it and act accordingly we cannot possibly be defeated. If we reject it or ignore it we cannot possibly survive.

Let me, therefore, suggest two concluding thoughts: one, that each American, beginning tonight, will do well to make Franklin in this respect his exemplar; and the other that each by so doing will stand a chance of measuring up to Browning's immortal tribute to—

"One who never turned his back but marched breast-forward—
Never doubted clouds would break:
Never dreamed, tho' Right be worsted, Wrong would triumph—
Held—we fall to rise—are baffled to fight better
Sleep to wake."

Mr. Redding, after expressing appreciation to Mr. Pepper for his illustrious talk, then declared the meeting adjourned.

THE FRANKLIN INSTITUTE.

LIBRARY NOTES.

The Committee on Library desires to add to the collections any technical works that members would wish to contribute. Contributions will be gratefully acknowledged and placed in the library. Duplicates received will be transferred to other libraries as gifts of the donor.

Photostat Service. Photostat prints of any material in the collections can be supplied on request. Orders received in the morning are filled the same day. The average cost for a print 9 × 14 inches is thirty-five cents.

The library and reading room are open Monday, Tuesday, Wednesday and Friday from nine o'clock A.M. until five o'clock P.M., Thursday from nine o'clock A.M. until ten o'clock P.M., Saturday until twelve o'clock noon.

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NOTES FROM THE BARTOL RESEARCH FOUNDATION.

PROPORTIONAL COUNTER AMPLIFICATION AT LOW VOLTAGES.*

BY

M. E. ROSE AND W. E. RAMSEY.

The investigation of gas amplification in proportional counters has been extended to low voltages where the transition to ionization chamber behavior is observed. In order to avoid field distortion due to positive ion space charge, it is necessary to use a source of radiation which is not too strong. This, in turn, necessitates the measurement of very small ionization currents (of order 10^{-14} ampere) at low gas amplification. A counter has been designed which is capable of measuring the small ionization current without amplification and by a comparison with the observed amplified current at higher voltages, the amplification factor is directly obtained. In accordance with previous results, the low voltage gas amplification in polyatomic and simpler gas mixtures is qualitatively the same. From a comparison of the experimental results with the theoretical expression previously derived for the amplification factor it is concluded that at low voltages where amplification sets in the fluctuations in energy loss of the electrons initiating avalanches play an important role. These fluctuations correspond to a distribution in starting positions of the avalanches with the result that the amplification sets in gradually and at considerably lower voltages than would be expected on the basis of the observations at high voltages.

* An abstract of a paper which was published in full in *The Physical Review*, 61, 504 (1942).

THE PRODUCTION OF NEUTRONS AND PROTONS BY THE COSMIC RADIATION AT 14,125 FEET.*

BY

S. A. KORFF AND E. T. CLARKE.

The production of neutrons and protons in various substances by the cosmic radiation was investigated with proportional counters at the Mt. Evans Laboratory (barometer 46 cm.). Neutrons were studied with counters filled with BF_3 and cadmium absorbers. The neutron counter was surrounded by water, so that nearly all the neutrons should be slow, and also so that the neutrons measured should nearly all have been produced in the water, very few of those produced elsewhere reaching the counter. Protons were observed in counters filled with CH_4. The size distribution of ionizing events was determined. Coincidences between neutron counts and shower counts were observed, suggesting a connection between the neutrons and the soft component. Estimates are given of the rates of production in various substances, these being of the order of 10^{-3} to 10^{-4} per gram per second on Mt. Evans.

ON THE ELECTRICAL AND ANOMALOUS SCATTERING OF MESOTRONS.*

BY

RALPH P. SHUTT.

Photographs obtained without a magnetic field in a large counter-controlled cloud chamber containing lead plates of two different thicknesses have been analyzed in regard to the scattering of the mesotrons in lead. The theory of scattering developed by E. J. Williams has been used. The mathematical form of this theory makes it possible to eliminate the energy distribution of the mesotrons in comparing the observed scattering intensity in two lead thicknesses. The scat-

* An abstract of a paper which was published in full in *The Physical Review*, 61, 422 (1942).

* An abstract of a paper which was published in full in *The Physical Review*, 61, 6 (1942).

tering in a 5-cm. lead plate into angles greater than 4°, when compared to that in a 1-cm lead plate, is more than would have been expected on the basis of Williams' theory. The average cross section calculated for this anomalous large angle scattering agrees with the results obtained by Code but it is somewhat larger than that previously reported by Wilson. It is also noted that this cross section is in agreement with the interaction between mesotrons and nuclei computed by Marshak and Weisskopf when a spin of $\frac{1}{2}$ for the mesotrons and an energy distribution such as that computed by Hartree are assumed. Although these experiments are perhaps not yet able to distinguish between the scatterings to be expected from a mesotron spin of $\frac{1}{2}$ and that from a spin of 0, a spin of 1 seems to be definitely excluded since for this value of the spin the theory indicates a cross section of about 1000 times more than that found. It is noted that a possibility for an explanation of the observed anomaly still might be found in electromagnetic effects such as those leading to burst production by mesotrons or in attributing the anomaly to nuclear scattering of the proton component instead of mesotrons.

NOTES FROM THE BIOCHEMICAL RESEARCH FOUNDATION.

Electrophoretic Evidence for Complex Formation in Casein. A Correction.—LAURA E. KREJCI. In a recent publication (Krejci, Jennings and Smith, JOURNAL OF THE FRANKLIN INSTITUTE, **232**: 592, 1941) it was shown that at pH 7 the electrophoretic pattern of acid alcohol soluble casein exhibited asymmetries which indicated that of the three constituents, alpha, beta and gamma casein, two, alpha casein and beta casein, formed reversibly dissociable complexes. The asymmetries were described as follows: "Normally the concentrations in the anode (rising) arm are smaller than those in the cathode (descending) arm because of the dilution at the delta boundary; the concentration of beta casein, however, was greater in the anode arm than in the cathode arm, and the mobility was higher. Furthermore, in the anode arm the reduction in the concentration of alpha casein was greater than that predicted by the magnitude of the delta effect." The existence of reversibly dissociable complexes of alpha casein and beta casein accounted for these asymmetries in the following way: "In the anode arm, where the beta casein boundary migrated in a medium containing alpha casein, the concentration in the beta boundary was increased at the expense of the alpha casein concentration, and the mobility was enhanced as the result of the complex formation with this more rapidly migrating constituent."

In this paper the statement was made that "in the cathode arm, where the beta casein boundary migrated in a medium free from alpha casein, the complex was disrupted above the receding alpha casein boundary, and the concentration and mobility were those of uncombined beta casein." It is true that the beta boundary in the cathode arm migrated with the normal mobility of free beta casein, but the assumption that the concentration increments at the alpha and beta boundaries in the cathode arm were equal to the actual concentrations of alpha and beta casein, combined and free, was incorrect be-

cause it failed to take into account the effect on the concentration gradients of the difference in the mobilities of the free beta casein and the complex. The uncombined beta casein which gradually accumulated between the descending alpha and beta casein boundaries moved forward at a slower rate than the combined beta casein which lay in advance of the alpha casein boundary. This led to wider spacing of the free beta casein molecules above the alpha casein boundary, and to a reduction in the concentration per unit volume. The reduced concentration increment at the beta casein boundary was compensated for by an increased increment at the alpha casein boundary because of the change in the concentration of beta casein produced here by the reduction in mobility which accompanied dissociation of the complex. Owing to the dynamic equilibrium between alpha casein, beta casein and complex, the alpha casein which was liberated simultaneously increased the concentration of alpha casein at each horizontal plane in the boundary without changing the total increment across the boundary, and the increase was greatest in the upper parts of the boundary where the lower concentrations of alpha casein favored dissociation. As electrophoresis progressed, this preferential accumulation of liberated alpha casein in the upper half of the boundary raised the plane of half-concentration and caused a slight decrease in the observed mobility of the boundary; a further decrease was produced by the retarding effect on the alpha casein of the dynamic equilibrium with the less rapidly migrating complex. The alpha casein boundary in the anode arm was free from both these disturbances, and the mobility here was normal except for the delta effect. The concentration of alpha casein, combined and free, in the unchanged portion of the solution was greater than that indicated by the anode boundary after correction for the delta effect, but less than that indicated by the cathode boundary.

Longsworth and MacInnes (*Journal of General Physiology*, **25**: 507, 1942) have recently presented a theoretical discussion of complex formation and have given equations for computing the concentrations of the individual constituents. The concentration of the slower-migrating constituent, beta casein in this instance, is given by the expression

$$A_{\beta l} = A_{\beta c} \cdot (V_{ac} - V_{\beta c})/(V_{ac} - V_{\beta a\rho})$$

and that for the faster-migrating constituent, alpha casein, by the expression

$$A_{\alpha t} = A_{\alpha a} \cdot (V_{\alpha a} - V_{\beta a})/(V_{\alpha c} - V_{\beta a}\rho).$$

$V_{\alpha c}$ and $V_{\beta c}$ represent the volumes swept through by the alpha casein and beta casein boundaries respectively in the cathode arm of the U-tube, and $V_{\alpha a}$ and $V_{\beta a}$ are the corresponding volumes for the anode arm. $A_{\beta c}$ is the measured refractive increment at the beta casein boundary in the cathode arm of the U-tube, and $A_{\alpha a}$ is the increment at the alpha casein boundary in the anode arm. ρ is the dilution factor at the delta boundary.

It is interesting to examine the significance of these equations. In the former, $(V_{\alpha c} - V_{\beta c})$ represents the volume and $A_{\beta c}$ the concentration of the separated free beta casein. $V_{\beta a}\rho$ represents the volume through which the complex boundary would have moved in the cathode arm if dissociation had not occurred, and $(V_{\alpha c} - V_{\beta a}\rho)$ the volume which the separated complex would then have occupied. Since this is the volume of solution from which the separated free beta casein was derived, this is the volume which it should occupy to give the concentration in which it was present in the original solution. Similarly, since the quantities of free alpha and beta casein separated in the two arms of the U-tube must bear the same ratio to one another as the concentrations in the unchanged portion of the solution, the concentration of alpha casein in the original solution is given by the concentration to which the free alpha casein separated in the anode arm would be increased if it were compressed to the same hypothetical volume.

These equations have been applied to the casein data reported in the previous paper. The results, expressed in refractive increments, are given in Table 1. The percentage composition indicated by these figures, assuming equal specific refractive increments for the three constituents, is given also. The concentration of alpha casein is lower than the value given in the previous paper, and that of beta casein higher.

Of the five types of equilibria distinguished by Longsworth and MacInnes, acid alcohol soluble casein appears to belong to the fifth; the velocity constants for the reactions of combination and dissociation are apparently of the same order of

TABLE I.

Electrophoretic Analysis of Acid Alcohol Soluble Casein.
pH: 7.0. Temperature: 0° C. Buffer: 0.15 M NaCl, 0.01 M phosphate.

Experiment Casein Preparation	1 *A*	2 *B*	3 *B*	4 *B*
Boundary concentrations (in refractive increments × 10^5)				
$A_{\alpha c}$	214	165	121	123
$A_{\beta c}$	22	18	18	16
$A_{\gamma c}$	22	23	20	20
A_c total	258	206	159	159
$A_{\alpha a}$	167	130	106	102
$A_{\beta a}$	40	31	25	26
$A_{\gamma+\delta}$	49	45	28	31
A_a total	256	206	159	159
$p=(A_{\alpha a}+A_{\beta a})/(A_{\alpha c}+A_{\beta c})$	0.88	0.88	0.94	0.92
Migration volumes (in centimeters of cell length per hour)				
$V_{\alpha c}$	0.800	0.760	0.790	0.848
$V_{\beta c}$	0.272	0.355	0.355	0.420
$V_{\gamma c}$	−0.082	0.050	0.050	0.065
$V_{\alpha a}$	0.925	0.857	0.860	0.930
$V_{\beta a}$	0.612	0.512	0.488	0.570
$V_{\gamma+\delta}$	−0.037	0.075	0.028	0.072
Calculated concentrations (in refractive increments × 10^5)				
$A_{\alpha t}=A_{\alpha a}\cdot(V_{\alpha a}-V_{\beta a})/(V_{\alpha c}-V_{\beta a}\rho)$	199	145	119	114
$A_{\beta t}=(A_{\alpha c}+A_{\beta c})-A_{\alpha t}$	37	38	20	25
$A_{\beta t}=A_{\beta c}\cdot(V_{\alpha c}-V_{\beta c})/(V_{\alpha c}-V_{\beta a}\rho)$	44	23	23	21
$A_{\alpha t}=(A_{\alpha c}+A_{\beta c})-A_{\beta t}$	192	160	116	118
$A_{\alpha t}$, average	195	153	117	116
$A_{\beta t}$, average	41	30	22	23
Percentage composition (computed from $A_{\alpha t}$, average, and $A_{\beta t}$, average)				
Alpha casein	76%	74%	73%	73%
Beta casein	16%	15%	14%	14%
Gamma casein	8%	11%	13%	13%

magnitude, and both are large with respect to the rate of electrophoretic separation. Because of the preponderance of alpha casein, the equilibrium concentration of free beta casein is probably very low; without knowledge of this concentration the composition of the complex cannot be determined.

In the previous paper the electrophoretic behavior of the acid alcohol soluble casein was compared with the sedimenta-

tion behavior of the casein of oxalated milk plasma in the presence of low concentrations of calcium ion (Philpot, *Proceedings of the Royal Society*, **B127**: 21, 1939). Although both indicate a rapidly adjustable equilibrium between unassociated units and association products, the comparison was hardly warranted; the sedimentation constant of the unassociated unit in oxalated milk plasma is 6, while that of acid alcohol soluble casein is 13.6 (Svedberg, Carpenter and Carpenter, *Journal of the American Chemical Society*, **52**: 241, 1930). Acid alcohol soluble casein is apparently homogeneous in the ultracentrifuge. In view of the electrophoretic evidence for reversibly dissociable complexes, it seems probable that because of the rapid adjustment of equilibrium the individual complex molecules cannot persist long enough to form a separate sedimentation boundary; instead the mixture sediments with a single boundary at a rate which is somewhat greater than the sedimentation rate of the unassociated unit.

BOOK REVIEWS.

THE RECOVERY OF VAPORS, by Clark Shove Robinson. With special reference to volatile solvents, 273 pages, illustrations, 16 × 24 cm. New York, Reinhold Publishing Corporation, 1942. Price $4.75.

That commercial recovery of vapors, generally, has only recently become of importance is due to the increase in economic value of the vapors, the industrial demand for the vapors, and the expansion of the recovery technique to new fields. Those interested in the subject, in the past, will recall the book, by this author, on "The Recovery of Volatile Solvents" published some twenty years ago. The present book not only brings the subject matter of the old book up to date but includes the more recent developments.

The beginning of the treatment deals with those elementary principles of chemical engineering bearing on the subject. These are blended into the more basic principles of vapor recovery. Thus, at the start, the discussion centers on gases and vapors, vaporization, distillation, and condensation. Then, adsorption is taken up leading to the recovery of adsorbed vapors and commercial activated carbon systems. Among the latter, there is described the Columbia Activated Carbon System of Carbide and Carbon Chemicals Corporation, the development of which was carried out by Dr. N. K. Chaney. Later, the Anticarbone System is described, which is useful in recovering gasoline from natural gas.

Condensation is the next method of vapor recovery discussed. Here, in order, there is covered condensation at constant pressure, with cooling water both where the condensing vapor is soluble in the cooling medium and where it is insoluble, and with refrigeration. The very important factor of the heat of vaporization, in the vaporizing solvent in the presence of inert gases, is given attention followed later by illustrations of applications of condensation. The topics of compression and cooling follow this. The use of liquids as absorbing media is the third method of vapor recovery taken up. Likewise, this gives principles of the recovery and a description of typical scrubbing apparatus.

In the latter part of the book, there is a chapter devoted to special absorbents. This covers such absorbents as sulphuric acid, cresol, and tetrahydronaphthalene. A chapter on extraction by solvents completes the book.

The work is focused, definitely, on the subject with a sharp boundary line surrounding it. This is characteristic of the former book. Nothing outside of the boundary line is covered, but all of the fundamental principles within the subject are here. They are put forth in an easily understandable manner. The book contains basic theory of practical value especially to the beginner in this field.

R. H. OPPERMANN.

THE "PARTICLES" OF MODERN PHYSICS, by J. D. Stranathan, Ph.D. 571 pages, illustrations, 16 × 24 cm. Philadelphia, The Blakiston Company, 1942. Price $4.00.

This book contains material given in courses for undergraduate students at the University of Kansas in modern physics. The progress of the subject and

the almost unlimited possibilities of the future make the course for such students of great value, and its presentation must necessarily be made with care. The selection of "particles" of modern physics, as the central point of the study, is unusual and bears close examination, as to the order of progression, through the book as well as the extent of detailing around this central point.

The treatment opens with a discussion of the conduction of electricity through gases. This gives a good account of the manner of formation of ions, their behavior, the mobilities of ions, and the recombination of ions. The nature of electricity is next taken up, which of course, covers the electronic charge. Various types of discharge are noted before cathode rays are covered. This latter illustrates well the skill that is attendant throughout the book in logical procedure in the subject matter. At first, there is a brief discussion on what are cathode rays. This is followed by short mentioning of several methods of measuring the velocity of cathode rays, and a description of the actions of an electron which is projected with high velocity into a magnetic field. Then comes the treatment on the ratio of charge to mass of the electron leading to the variation of mass with velocity.

Topics, subsequently treated, include positive rays—isotopes; photons; *a*, *B* and *r* rays; the positron; the neutron, atomic nuclei—artificial disintegration; cosmic rays; the mesotron; and finally an examination of the question of the concept of the actual nature of light. At the end of the book, there is a comprehensive subject and author index.

The work covers a broad territory quite completely. Numerous references are noted throughout. A feature is the invaluable brief sketches in the body of the text outlining progress to date. This makes not only for greater knowledge but lasting impressions. The book should have much use in its niche in the educational system.

R. H. OPPERMANN.

ELEMENTS OF HEAT TRANSFER AND INSULATION, by Max Jakob and George A. Hawkins. 169 pages, illustrations, 15 × 24 cm. New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1942. Price $2.50.

Problems of heat transfer and insulation are encountered in all kinds of engineering. It is, therefore, an important subject which, at least in its fundamentals, should be presented to all undergraduate students in engineering. The present book has this for its purpose. It is restricted to basic principles and their application to simple problems.

The plan of the book is based on the three different types of heat transfer: conduction, convection, and radiation. Consideration is given to basic equations governing each type, and to cases dealing with a combination of two or more of the ways. The book opens with a chapter on thermal conductivity, with particular attention to low and high temperature insulating materials. This leads to chapters on conduction of heat in the steady state and the unsteady state; the former dealing with cases where the surface temperatures of the bodies are known, and the presentation of equations in the latter being assisted by graphical representations. The subject of heat sources within a heat-conducting body is next discussed, which ends the treatment on conduction.

In what may be termed the second part of the book, there is illustrated best, the skill of presentation. This is on convection, and there is shown that natural convection heat transfer theory is complicated because of the many variables involved in the solution of a particular problem. Later, some of the simplified equations which apply to a limited range of experimental data are given. Heat transfer by forced convection, by the combined effect of conduction and convection, and heat transfer in condensing and boiling are subjects which complete this part of the book.

Radiation is the next general subject. This is presented as a kind of wave motion and the concept of a perfect black body. Quite a thorough discussion is given which is followed by a treatment on the combined effect of conduction, convection, and radiation. The latter part of the book gives illustrations of some applications of heat transfer in experimental engineering, and the interdependence of heat transfer and surface friction. There are problems for exercise and lists of references at the end of chapters, and there is a comprehensive subject index in the back of the book.

The authors cover the subject, adequately, for undergraduate engineering students. The book is an exceptional text on the subject of growing importance.

R. H. OPPERMANN.

PUBLICATIONS RECEIVED.

Training Manual for Auxiliary Firemen, edited by Horatio Bond, W. Fred Heisler, and R. J. Douglas. 406 pages, illustrations, 14 × 20 cms. Boston, National Fire Protection Association, 1942. Price $1.50.

Chemical Refining of Petroleum, by Vladimir A. Kalichevsky and Dr. Bert Allen Stagner. Revised edition, 550 pages, illustrations, 16 × 24 cms. New York, Reinhold Publishing Corporation, 1942. Price $7.50.

Physical Science, by William F. Ehret, Leslie E. Spock, Jr., Walter A. Schneider, Carel W. van der Merwe, and Howard E. Wahlert. 639 pages, illustrations, 16 × 24 cms. New York, Macmillan Company, 1942. Price $3.90.

CURRENT TOPICS.

Operating Experience on Pioneer Windowless Plant. (*Engineering News Record*, Vol. 128, No. 21.) The first windowless factory in the United States, accurately described by its designers and builders, The Austin Co. of Cleveland, Ohio, as a "controlled-conditions plant" is owned and occupied by the Simonds Saw and Steel Co. of Fitchburg, Mass. Although built in 1931, it stood idle during the depression, and not until 1939 was it placed in service. Since that date, however, careful records have been kept of operating experience and some of the results have recently been released by the plant superintendent. Those pertaining to lighting and air conditioning are particularly significant. A careful record for example was kept of the life of fluorescent tubes. The record shows during the first nine months of operation that the tubes averaged 3800 hr. A subsequent period of 18 months showed an average of 4800 hr. per tube. No information is available as to whether the tubes have a longer useful life if they burn continuously. At present, however, the Simonds plant is operating around the clock on three shifts, six days a week, which means that the lights are turned out only once and turned on once in a period of seven days. There has been no noticeable drop in the efficiency of tubes as they grow older. All of the fluorescent units are thoroughly washed twice a year, and this helps to maintain the lighting efficiency. The cinder block side walls, which were left unpainted when the plant was originally completed, were painted about a year and a half ago, and are today practically free of dust and dirt as a result of the efficient control of atmosphere throughout the plant, which is crowded with heat treating and grinding machinery. A special white paint, developed for this service, has in no way destroyed the acoustic properties of the cinder block. The ceiling, which was painted yellow just before the plant went into operation, is also entirely free of dust and discoloration in most places throughout the plant, although a fine powdery film has formed at certain locations above heat-treating furnaces, forges and certain rough and wet grinding operations. Vacuum cleaning restores the original ceiling condition without any use of paint.

R. H. O.

New Devices Aid Rapid Communication in Forests.—Two new devices in emergency radio communication are aiding the U. S.

Department of Agriculture's Forest Service in this year's fight against fires which might seriously impede the war effort. One is a simplified radio antenna perfected recently at the Forest Service's Radio Laboratory. Another is an improved receiver for use on mobile fire control equipment. Pioneering in forest radio activities for the past 15 years, the Forest Service has developed specialized equipment to meet the problems of rapid communication in remote areas and rough terrain. Because prompt attack is necessary to keep fires from developing into large and costly conflagrations, quick and reliable communication is vital to effective fire control. Approximately 3,500 semi-permanent mobile and portable radio stations are now in operation in National Forests, and more than 1,000 are maintained by State forestry agencies. Out of the Forest Service Radio Laboratory have come several types of radio equipment, including portable sets rugged enough for transportation on mule back, and the two-way "pocket" voice radiophone weighing only six pounds, first used two years ago by the Service's parachute fire fighters. Similar equipment has since been adopted by a number of other federal, state and local authorities concerned with portable radio communication. The new forest radio antenna has no insulators, requires no elaborate installation, and can be pretuned before installation. Costing but a small fraction of what the usual commercial antenna costs, it is called the PD ("plumber's delight") antenna by forest rangers because it can easily be made from simple materials like pipe and fish poles and installed with the aid of a few plumbers' tools. The fact that no insulation is necessary prevents power losses and reduced efficiency due to insulator leakage. Resistant to snow and ice, the antenna is expecially suitable for lookout stations at high elevations. It is equally effective on wood and metal buildings. Another asset is that instead of representing a lightning hazard, it acts as a lightning rod, adding to the safety both of the structure to which it is attached and the occupants. Reduced to barest essentials, the PD antenna consists of a vertical radiator, working against a ground established by four horizontal quarter-wave radials. For Forest Service radio frequencies, the antenna is only six to seven and one-half feet long.

R. H. O.